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Package quality verification during NPD in Case company

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TIIVISTELMÄ

Lappeenrannan teknillinen yliopisto
LUT School of Energy Systems
LUT Mechanical Engineering

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Pakkauksen laadun varmistaminen tuotekehityksen aikana

Diplomityö

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67 sivua, 31 kuvaa, 5 taulukkoa ja 2 liitettä

Tarkastajat: Professori Juha Varis
Professori Kaj Backfolk

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Työssä tutkittiin laatutyökalujen integroimista tuotekehityksen aikana osaksi kuluttajapakkauksen pakkauskehitystä. Pakkauskehitys on tärkeässä osassa osana tuotekehitysprosessia yhä kovenemassa kilpailussa asiakkaiden vaatimukset mukaan lukien.

Suunniteltaessa kuluttajapakkausta, joka huomioi asiakkaan ja varmentaa pakkauksen riittävän laadun sen saavuttua markkinoille tuotekehityksen tueksi, on olemassa erilaisia työkaluja. Tässä tutkimuksessa käytettiin Voice of Customer (VoC), Quality Function Deployment (QFD) ja Design Failure Mode and Effects Analysis (DFMEA) -menetelmiä pakkauskehityksessä. Lähtien asiakkaan äänestä ja miten se muutetaan pakkauksen tekniseksi ominaisuudeksi pakkauskehityksessä ja kuinka mahdolliset riskit otetaan huomioon tuotesuunnitellussa.

Työn aikana laadittiin kysely, jolla pyrittiin kartoittamaan asiakkaan haluamat ominaisuudet kuluttajapakkauksessa. Työssä sovellettiin laatutyökaluja, joilla priorisoitiin asiakkaan vaatimukset ja kuinka ne varmennetaan tuotekehityksen aikana.

Tuloksena saatiin käytettävät työkalut NPD prosessin aikana, joilla systemaattisesti varmennetaan pakkauksen laatu ottaen huomioon asiakkaan vaatimukset ja mahdolliset riskit uuden pakkauksen suunnittelussa. Tuloksia voidaan hyödyntää jatkossa pakkaus-suunnittelun tukena. Aiheita ovat muun muassa systemaattinen pakkauskehitys, kuluttajalähtöinen pakkauskehitys, tuotekehitysprosessi, laaduntalo, pakkaustestaus.

ABSTRACT

Lappeenranta University of Technology
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Package quality verification study during NPD in Case company

Bachelor's thesis

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67 pages, 31 figures, 5 table and 2 appendices

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Professor: Kaj Backfolk
Supervisors: Marko Halttunen and Jussi Kyyhkynen
Keywords: package development, NPD process, paperboard, package testing, Kano, QFD, DFMEA

The project examined the integration of quality tools during product development process into consumer packaging development. Packaging development is an important part of the product development process, when considering customer requirements in increasingly growing market competition.

When designing a consumer packaging that attracts customer attention and certifies the needed quality of packaging when it comes to market there are specific tools available supporting the product development. In this study Voice of Customer (VoC), Quality Function Deployment (QFD) and Design Failure Mode and Effects Analysis (DFMEA) methods have been used in packaging development. Starting from the voice of customers and how these are translated into a technical feature of the packaging development and how potential risks are considered in the early product design phase.

During the research, a questionnaire was prepared to identify the desired characteristics of the customer needs in the consumer packaging. Quality tools were used to prioritize customer requirements and how to verify them during product development process.

As a research result, the tools were used during the NPD process which systematically verify the quality of the packaging considering customer requirements and possible risks in the design of the new packaging. The results can be utilized in the future as supporting material of packaging design.

Topics include systematic packaging development, consumer-oriented packaging development, product development process, house of quality, package testing.

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Markus Onnela

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LIST OF SYMBOLS AND ABBREVIATIONS

DC	Distribution center
DFMEA	Design Failure Mode and Effect Analysis
EMEA	Europe, The Middle East and Africa
EU	European Union
FIC	Fiskars Inspection check
FBB	Folding Boxboard
GS1	General Specifications Standard
HOC	House of Quality
ISTA	International Safe Transit Association
NPD	New Product Development
MBX	Master box
PRG	Product Requirement Guideline
QFD	Quality Function Deployment
RPN	Risk Priority Number
RBX	Retail box
SBU	Strategic Business Units
SKU	Stock Keeping Unit
VoC	Voice of Customer

1 INTRODUCTION

The subject of the thesis was developed by Fiskars's need to develop the packaging quality assurance process to be more systematic and to serve specific product need of use. Packaging has an important role in protecting products throughout the Fiskars supply chain and ensuring packaged quality and characteristics unchanged from the manufacturer to the consumer. Packaging also gives information about the products, is a good communication channel and helps consumers make a purchase decision. Fiskars is operating globally and wants to distribute products efficiently from the Distribution Center (DC) to the customers. The same packaging solution must comply with the requirements of many markets to avoid needs of re-packaging or re-labelling products. The main Fiskars Functional Business Unit products are axes, scissors and gardening hand tools which have their own individual packages for their initial purpose.

Alongside my master's studies I have been working as a quality engineer in a Fiskars Functional Strategic Business Unit (SBU) organization. I have been responsible for quality topics which are related to either New Product Development (NPD) or existing product portfolio products. The packaging department is part of the NPD team inside of Fiskars Functional Business Unit.

Currently there is no systematic packaging quality verification done in the Fiskars Functional SBU and there is an interest to introduce a Fiskars specific packaging quality assurance process in the packaging team. The main purpose of the quality assurance process is to create internal product specific packaging standard requirements. The goal of this Master's Thesis is to present a selected product specific packaging assurance process case and it to be as a starting point of these internal standard requirements.

1.1 Fiskars

Fiskars was founded in 1649 as an ironwork and is now the oldest Finnish company. Fiskars has grown into an international company that manufactures consumer products for home and garden use. Fiskars has two main strategic business units: Fiskars Functional and Fiskars

Living. Today, Fiskars serves consumers and customers around the world with brand portfolios, including internationally renowned brands such as Fiskars, Gerber, Iittala, Royal Copenhagen, Waterford and Wedgwood. According to the company's mission, Fiskars builds the family of iconic lifestyle brands. The company vision is to have a positive and lasting impact on people's lives and making the everyday extraordinary. The values of the company encourage employees to be innovative and responsible, but also to value honesty and encourage everyone to do teamwork. Fiskars key figures are highlighted in below Fig. 1. (Fiskars 2018)

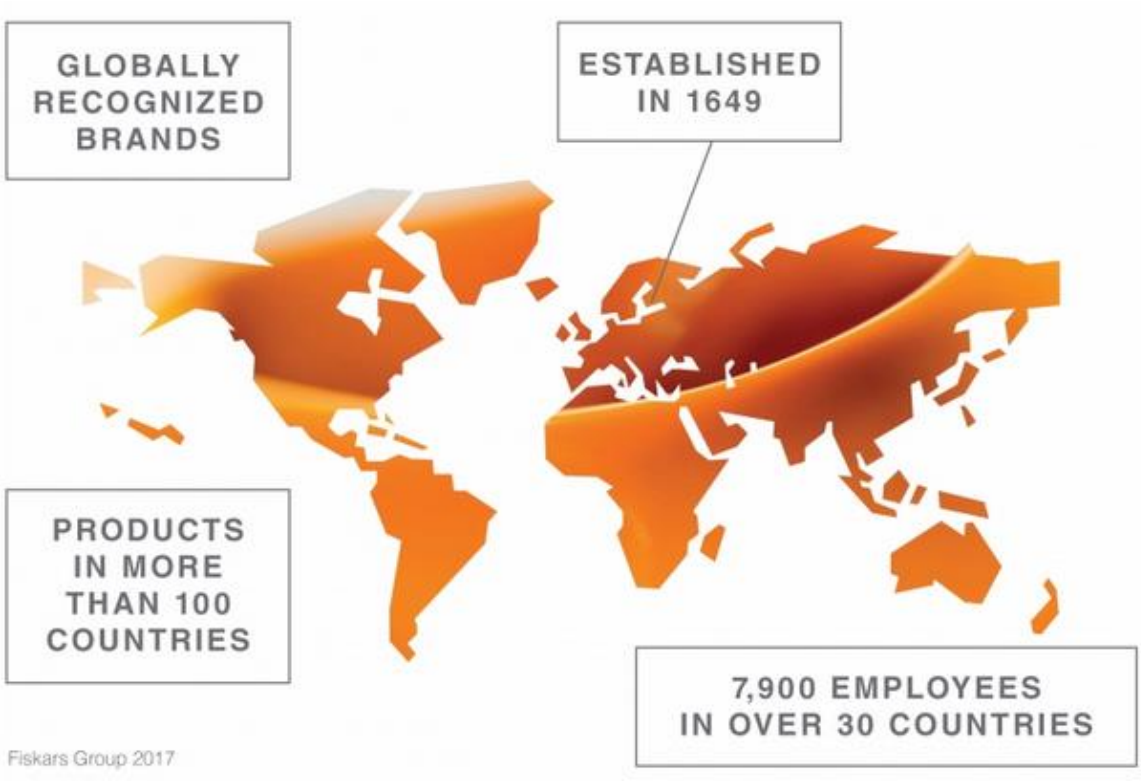


Figure 1. Fiskars in a nutshell. (Fiskars 2018)

At Fiskars, all begins with understanding the consumers and their needs. The intention is to understand consumers deeply as well as product and portfolio development and marketing activities. Consumer insight is very important and has a critical role in guaranteeing a true omni-channel experience across all the channels and platforms, both physical and digital. To make this all happen to the brand, marketing and product development are in key roles to ensure this. In addition, the brand's purpose, marketing concepts and activities are defined by brand and marketing to present the offering in the most relevant way across all markets and consumer touchpoints. From a manufacturing and sourcing point of view Fiskars supply chain plays a critical role for ensuring quality, cost efficiency and sustainability in this chain.

Fiskars has own manufacturing units in Asia, Europe and North America, which are complemented by a network of suppliers. The supply chain focuses on ensuring that the product quality, production methods and all the social and environmental aspects live up to the requirements of sustainable ways of working. (Fiskars 2018)

1.2 Research problem

The packages are the main role in Fiskars supply chain protecting product quality from supplier to customer. The main problem is that there is no systematic way of working or process to verify package quality and its specific characteristics in different kind of products. Some of the packaging related activities are done but there are some different practices inside of Fiskars. Also, distribution center locations have been changed and globalization affects some new perspectives for distribution of products and its package. Currently Fiskars has 27000 SKU (Stock Keeping Unit) and products from garden to kitchen. Each Fiskars product requires some special features for package to ensure e.g. safety in kitchen knives. Currently there has been seen that there is a possibility to improve the packaging process to be more systematic and which serves the main purpose of the product better.

The research was started through a research problem and the main research question was defined as Develop the current packaging quality assurance process.

The main research question was divided into the following sub-questions:

- How to verify packaging quality?
- How to define the right quality requirements?
- Which tools to be used when monitoring/checking packaging quality?
- How to document and report packaging quality in Fiskars?

1.3 Goals and delimitations

The aim of this thesis is to implement a Fiskars SBU Functional systematic packaging quality control process. In addition, the aim is to implement main tools for how the product package is to be verified in Fiskars SBU Functional and finally how it is to be documented and reported in the future. Specific case products were used in the internal testing lab to verify package quality. At the starting point of this work, we decided to focus only on tertiary (consumer) packaging. Some of this study parts could be used with adaptations also for other

types of packaging. Company confidential material limitations have also been done and some of the processes are presented in a limited level. Some findings are also limited and can show the potential of further research.

1.4 Structure of report

The work is divided into two different theories and how those are implemented. The first part (theory) examines packaging quality assurance tools/methods and testing procedures. The theoretical part also focuses on generally on the NPD process and how packages are part of it. The second part (empery) focuses on the practical implementation and their different phases. In the final part we look at the results and impacts.

1.5 Current state analysis

Before we initiated the study, we analyzed the current state of the Fiskars package development. Fiskars already has a systematic NPD process in use on the product development side and packaging department has their own way to follow package development during NPD. Also, there is not a systematic way to track package verification during NPD e.g. who has done what, what has been tested and also in many cases documentation is missing. Quite often package activities are performed at a later part of the product development process.

2 RESEARCH METHODS

Data search was carried out by studying databases and scientific articles available at Lappeenranta University of Technology. In addition, the theory information seeking carried from the library at Lappeenranta University of Technology and at Google Scholar.

2.1. The information retrieval methods used in the literature study

The information search was limited to just for these headwords to find the information available as much related to packages and its development. The databases used were Scopus and Helmet database search. Fig. 2 shows the number of scientific publications in the Scopus database as a function of time with the term "package development". The search was limited starting from 1990 to 2019 year of publication for all types that belonged to the "package development " topic. When looking at the total result there were totally 753 573 hits for “E-article” which is the biggest group in the scientific publications in this area.

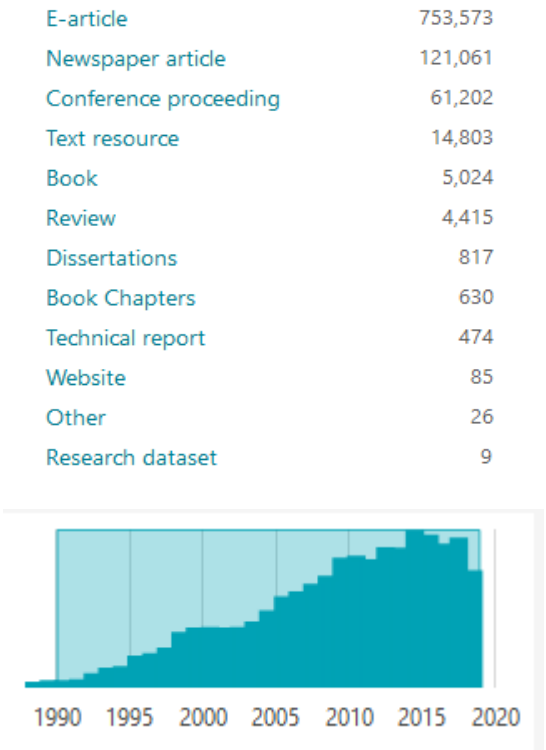


Figure 2. Number of sources from the Scopus database by "Package development".

It can be noticed from the graph that the scientific publications start increasing from 2005 and has been doubled when entering the present. Packaging development publications are

quite often considered from a logistics or marketing point of view. A research study which has carried out in Lund University of Sweden has collected package development evolution in this increasing time frame. Also, more systematic packaging development research has published in this time. According to Olsson, Nilsson and Jonson (2007) ‘’evolution of the packaging logistics research area publication 2007 theory in packaging logistics describe that is often delimited to packaging, focusing either on technological aspects example of packaging features, or on marketing aspects or branding’’. The holistic view of packaging logistics related to overall business systems is however not covered by researchers nor included in related scientific journals. Based on the Olsson et al. systematic approach logistic and effectiveness package related publications are collected between 2004 and 2007 in below Table 1.

Table 1. Publications related to packaging logistic and effectiveness 2004 - 2007. (Olsson et al, 2007, p.13)

Author(s)	*Title*	*Focus*	
Cochran and Ramanujam (2006)	Carrier-mode logistics optimisation of inbound supply chains for electronics manufacturing	optimisation model for carrier-mode selection	Logistics efficiency focus
Chan et al. (2006)	A systematic approach to manufacturing packaging logistics	systematic approach to manufacturing of packaging logistics	
Gonzalez-Torre and Adenso-Diaz (2006)	Reverse logistics practices in the glass sector in Spain and Belgium	reverse logistics	
Clark et al. (2006)	Radio frequency identification (RFID) performance: the effect of tag orientation and package contents	RFID technology in material-handling activities	
Jahre and Hatteland (2004)	Packages and physical distribution: Implications for integration and standardisation	leanness and agility in packaging contexts, standardisation	
Engelseth 2007)	The role of the package as an information resource in the supply chain	packages can be regarded as an information source and carrier	Effectiveness and value
Dominic (2005)	Integrating Packaging Suppliers into the Supply/Demand Chain	VMI solutions involving packaging	
Rundh (2005)	The multi-faceted dimension of packaging - Marketing logistic or marketing tool?	packaging in the supply chain, customer value	
Löfgren (2006)	The leader of the pack – A service perspective on packaging and customer satisfaction	packaging as product-related attribute affecting the customer’s experience of products	
Mollenkopf el. al. (2005)	Assessing the viability of reusable packaging: a relative cost approach	reusable packaging	Environmental

In traditional product development literature, theory is generally used in life cycle thinking, whereas the continuous development of packaging logistics in the research area is the overall management of product / packaging development and supply chain integration into the life cycle perspective.

When considering systematic approach for the packaging development process methodology as a Quality Function Deployment (QFD), only a few articles were found which focus on package development e.g. Paulo (2013, pp.419-433) benchmarking QFD application for developing packaging products; report case studies conducted in a company in Italy that produces packaging systems, in comparison with a Brazilian company within a similar industrial sector. The paper compares those two cases in terms of quality function deployment (QFD) usage and discusses the lessons learned from the cases.

2.2 Literature Review

The literature sources used in the research are based on the theoretical literature of the research topic. When searching for sources, the aim was to find literature that would have been published over the past 20 years. Most of the literature used in the study was in English.

The base of this research is the book "Product Design and Development" where Ulrich and Eppinger (2007) describe product development 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 book blends the perspectives of marketing, design, and manufacturing into a single approach to product development. The book describes how the product was the only competitive factor in the market, and only engineering design was the most important task for achieving competitiveness. Since then, focus has shifted to customers' needs and today it is important to understand the multidisciplinary approach to product development. Successful product development is a good product and manufacturability. The final activities before the successful launch of the product are distribution and sale.

Quality tools literature review has been described as commonly used in continuous improvement process and how provide systematic approach to ensure that new products meet or exceed customer expectation.

2.3 Completion of the study

The study was started in the beginning of 2018 by collecting and reviewing the material published in the subject area as well as by other companies performing with package development. When planning the basis of the package development, the knowledge of the

current state of the research was studied, and problems and shortcomings were identified in the present work. When the operating model was established based on the research topic, the main Six sigma verification tools were chosen to verify the systematic development of packaging. Six sigma quality tools have systemically been used in product development process and these tools will have integrated to part of packaging development process in this research study. Simply case projects were selected where tools were to be used and case specific package quality tools activities were to be done during research.

This thesis is the practical basis during a NPD project, which investigates the package mechanical quality and how package is verified by specific quality tools during the NPD process. In addition, the packaging process and documentation is studied. Selected tests and specific products from the NPD portfolio has been selected just for this case project. Fiskars internal lab is to be used as a verification purpose. Package mechanical tests are carried out based on project trial run schedule.

3 LITERATURE REVIEW

The literature provides a link and approach how package quality can be verified by using systematic quality tools starting from consumer requirements. Main six sigma quality tools and package functions are presented in this part. First it reviews different package roles in the supply chain, package types and what I needed for package from customer point of view. Then package development process and mechanical testing part were studied during NPD and covered the link to the practical part through literature.

3.1 Purpose of package

Packaging has a several functions; the fundamental role is to deliver the product to the consumer in perfect condition. According the Paine (1990) the definition of packaging is "a coordinated system of preparing goods for safe, efficient and cost-effective transport, distribution, storage, retailing, consumption and recovery, reuse or disposal combined with maximizing consumer value, sales and hence profit". Also, good packaging uses only as much of the right kind of material as necessary to perform this task. (ECR Europe 2009, p.7)

According the Consumer goods forum (2010, p.6) package main functions are:

- Protect the product
- Promote the product
- Provide information, on product, usage, health and safety, disposal, etc.
- Enable the convenient transportation and usage of the product
- Allow unitization of the product through the supply chain
- Support efficient handling of the product, again, throughout the supply chain

Table 2 lists the most important functions and their features of packaging. Each function of the package has a specific feature in different tasks during package life cycle. According to The Consumer Goods Forum (2010, p.5) a well-designed packaging will meet all these needed requirements and minimizing the economic and environmental impacts of both the product and its package.

Table 2. Functions of packaging (ECR Europe 2009, p.7)

Function	Features
Protection	• Prevent breakage (mechanical protection) • Prevent spoilage (barrier to moisture, gases, light, flavours and aromas) • Prevent contamination, tampering and theft • Increase shelf life
Promotion	• Description of product • List of ingredients • Product features & benefits • Promotional messages and branding
Information	• Product identification • Product preparation and usage • Nutritional and storage data • Safety warnings • Contact information • Opening instructions • End of life management
Convenience	• Product preparation and serving • Product storage • Portioning
Unitisation	• Provision of consumer units • Provision of retail and transport units
Handling	• Transport from producer to retailer • Point of sale display
Waste reduction and recycling and reuse of by-products	• Enables centralised processing and re-use of by-products • Facilitates portioning and storage • Increases shelf life • Reduces transport energy

Usually packaging tasks include product marketing and product information with different markings. Example labels on food packaging have been regulating by law instruments. The packaging may include, inter alia, condition of use and advice on the instructions for use. Packing labels, the safety of the product can be increased, for example, by explaining how to open the product and is handled appropriately to avoid damaging the product. Different code method in packages enable the use of order and information systems. Marketing point of view the packaging is part of the product image creation, as many products are identified packaging. (Järvi-Kääriäinen & Leppänen-Turkula 2002 , pp. 9-17)

3.2 Packaging Classification

Packaging can be classified into different levels depending on the type of industry. There are different concepts how packaging levels are dived across different industries. Different packaging levels are classified as a primary, secondary or tertiary as showed in Fig. 3 (Johnsson, 1998). Fig. 3 describe package classification in a different position of package life cycle.

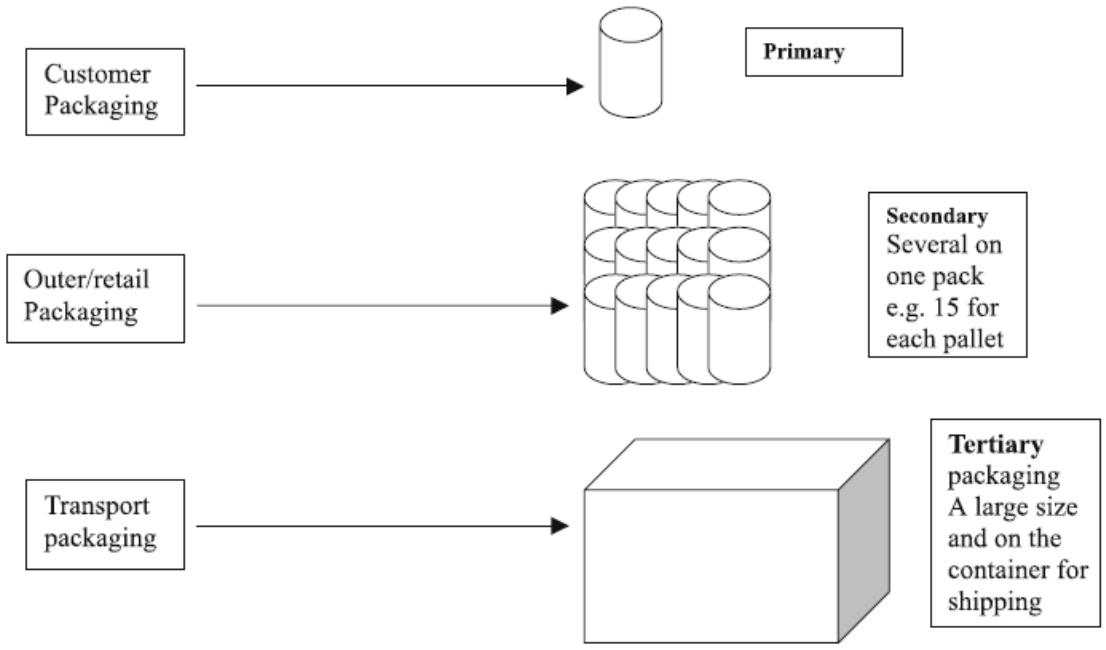


Figure 3. Packaging levels. (Johnsson, 1998)

According ECR (2012, pp. 12-15) the main purpose of the primary packaging is to make the product accessible and attractive to the customer, while it main objective is protects and preserves the properties of the product. The consumer should also be able to easily identify and obtain information about the product. Primary package must carry bar code and they should be labelled in accordance with the GS1 standard. The consumer packaging may contain a list of ingredients, instructions for product use, expiration date, and information on who should contact the product information. The logistical point of view consumer packages should be easy to stack and adapted to the shelf space. It should also be easy to handle for the consumer when considering for package opening, closing, and recycling features. It has been concluded that primary packaging also should ease for production, e.g. by being easy to fill and seal.

The secondary packaging also called retail package is a packaging that contains several primary packages and one of its main functions is to make the handling of the products easier at the selling point. Secondary packaging also protects and hold several primary packaging's together until they are taken use in sales area. In case of to place secondary packaging directly on the shelves in the stores so retailers prefer the ability to place secondary way that

they do not have to unload and place each item separately. Therefore, secondary packaging that meet the retail requirements for shelf space are also preferred. (ECR 2012, pp. 16-21)

The tertiary packaging is usually named as a transport packaging. Tertiary packaging facilitates the protection, handling and transportation of a series of sales units or hold consumer packages together until they reach the store shelf. Transport packaging module adaption is an important consideration to effective supply chain in the development of new products for optimizing degree filling of pallet and roller containers. Another purpose of tertiary packaging is to ease handling and provide stability during transportation and storage. (ECR 2012, pp. 16-21)

According the Lambert, Stock & Ellram (1998, p.33) packaging is very closely connected warehouse efficiency and effectiveness when considering warehouse and material management. Good packaging design have positive impact on layout and warehouse productivity and it will lead benefit to cost, package handling and service point of view. This can be achieved by letting the packaging interface well with the organization’s materials handling equipment and allow efficient utilization of storage space as well as transportation cube and weight constraints.

Fig. 4 describe packaged product life cycle and its typical steps. Each phase the packaging must meet critical requirements and constraints of this life cycle. Table 2 listed all relevant solutions how to make design effective and efficient package and product combination at each phase. Example changing consumer preferences and demographics, such as the reduction in household sizes, also have a major influence on product and package design (ECR 2009, p.9).

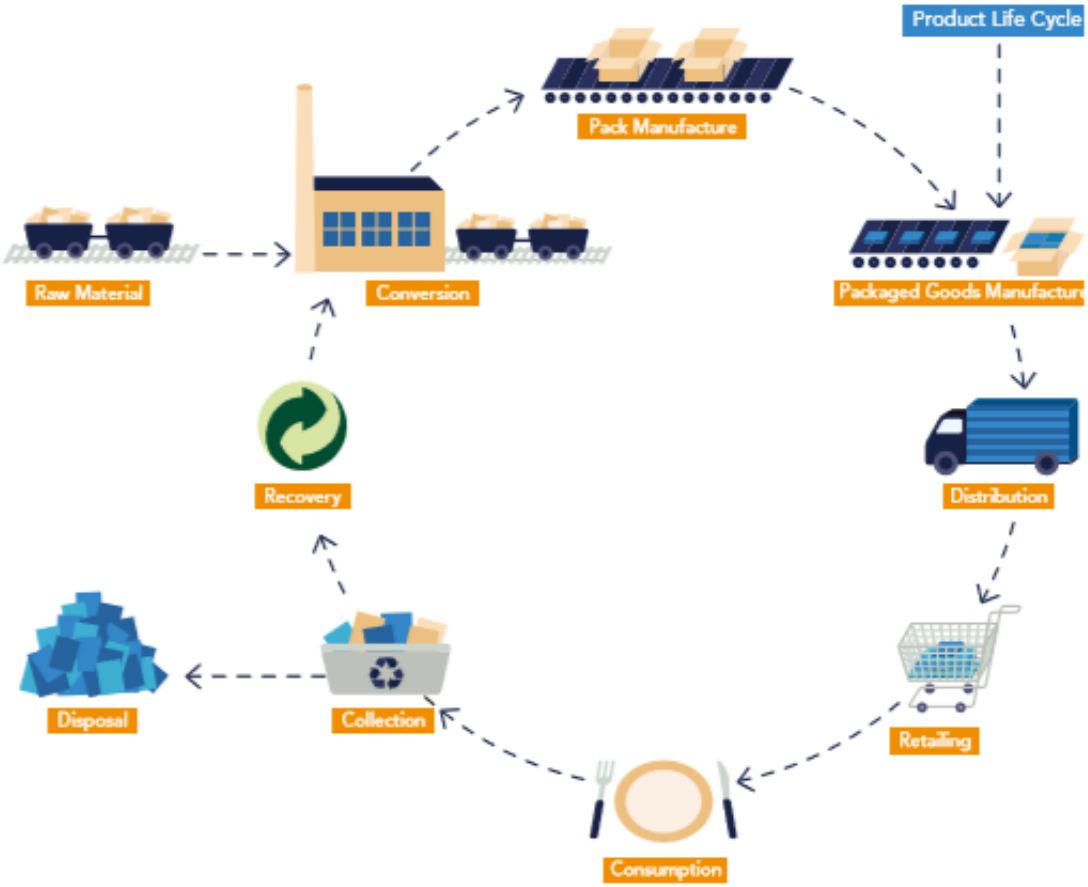


Figure 4. Packaged product life cycle (ECR Europe 2009, p. 9).

Package must meet consumer expectations in different levels during supply chain and fulfill market criteria's each step. Different package level has some main functions and purpose during package life cycle. Example tertiary packages should be designed way that is withstand distribution stresses during the whole supply chain. Each package level has some specific needs, and these needed to consider when designing packaging to meet all necessary requirements during package development. (The Consumer Goods Forum 2010, pp. 11-14)

3.3 Package consumer requirements

In a competitive market place, the consumer/customer views are important. More and more companies have the goal of making their organizations consumer/customer oriented to ensure that their businesses will be successful because they meet customer needs and expectations at the same time as they create customer values (Ahlgren & Ahlgren 2017 pp. 1-2. Narver et al. (2004 pp.334-347) highlighted that main challenge for organizations is to

improve their understanding about target customers' needs and wants so that improve products during NPD process.

Fast moving consumer good industry packaging is main role how product and brand are perceived in customers (Wansink & Huffman, 2001 pp. 8-15) and can affect consumers' purchasing decisions at the point of sale (Sara, 1990, p.29). Therefore, basic task of the packaging is to facilitate the identification of the product and to provide the consumer with more information about the product in addition to previous existing information / attitudes. The package can also correct consumer prejudices against the product, packaging, or brand and correct false information. For example, the colors are effective ways to increase product value in the shelf (Järvi-Kääriäinen et al., 2002 pp. 218-222). According the Rusko, Heiniö, Korhonen, Heilmann, Karjalainen, Lahtinen & Pitkänen (2010 p.24), consumer usually spends only a few seconds to making purchase process decision and this time frame very short to communicate complex features of product in package.

3.4 Package requirements consumer studies

According to the longitudinal study of changes in consumer packaging attitudes and preferences which carried out in 1998 and 2009 VTT Technical Research Centre of Finland, the characteristics most prevalent in consumer packaging were very similar 1998 and 2011 study (Korhonen 2010 p.56). Packaging information was ranked first in both the 1998 and 2011 data. Comfort, ease of openness and environmental friendliness are also important to consumers. According the research more and more consumers feel the benefit of keeping the product longer and less wasteful. Consumers feedback has been seen that overpacking of the product and package appropriate size is also important features to consider in package development. The environmental image of cardboard and paper is superior when compared to other packaging materials. Study also highlight that packaging that is competitive in design, but also easy to recycle is now growing in demand. (Korhonen 2010 pp.56-57; Rusko et al. pp. 9-87)

3.5 Packaging communication

Rusko (2011, p. 14) describe that ‘’The main task of the package communication is to promote product during moment of purchase. Good package communication makes the product attractive to the consumer, providing information about the product, and building a

brand image. The packaging should be addressed to the consumer as well at the time of purchase and in the operating situation and touches on the emotional level''.

Packet communication elements can be divided from the packaging design perspective into graphical and structural elements:

- Graphical elements: refer to visual packaging properties such as colors, images, text and typography.
- Structural elements: Package shape and size. (Rusko 2011, p. 14)

Graphical elements like colors give a package powerful message. Example black and dark colors communicate high quality of the product. Selected colors sometimes reflect the package trends and those might change very rapidly. (Rusko 2011, pp. 14-16)

When planning packet communication, it's important to know to whom the product is intended for. Package communication focusing on increasingly smaller target groups has become more common nowadays and generic marketing communication is no longer sufficient. Also, packaging communication is not just the texts and images found in the package, but an entity consisting of several elements. (Rusko, 2011, pp. 14-16)

3.6 Paperboards

When considering safety, handleability and reusability of packages packaging materials are defined in different ways and depends how much there were material used in these purposes. There is wide range of different packaging materials which can be used like a paperboard, corrugated cardboard, paper, wood and plastic which are some examples typical packaging material. The packaging materials should be carefully chosen according the purpose that they are intended to use. (Skander, 2015 pp 16-17)

Paperboard mean either one or multi-layered paper-like product with a high stiffness. Different layers can be manufactured several kinds of raw material types to achieve the desired properties. Paperboards are mainly used in different packaging as a packaging material. In addition to strength and stiffness, paperboard is also often required for good printability properties. The basis weights of different paperboard types are placed normally

150g / m^3 up to 600g / m^3. and compare to paper with a basis weight typically ranges from 30 to 100 g / m3 (Paulapuro 2000 p.134; Karhu 2007 p.21). According the Paulapuro (2000) and Karhu (2007) paperboards can be roughly divided into following three main categories according to their end use purpose:

- Consumerboards. Which consist cellulose board (SBS = Solid Bleached Sulphate), a white-washed recycled fiber board (WLC = White Lined Chipboard), folding boards (FBB = Folding Boxboard)
- Transport packages i.e. corrugated cardboard
- Special cartons

According to the Iggesund (2018) key paperboard characteristics are:
• thickness
• tensile strength
• stiffness
• surface smoothness
• flatness and dimensional stability
• moisture level in the board to control solvent retention

Paperboard demand as a packaging material has increased around the world. Main advantages compared to other packaging materials can be regarded as a recyclability and recycling also it is made from renewable natural materials and thus gives an environmentally friendly image of the product or package. In addition, the paperpoard packaging is lightweight compared to plastic or other packaging solution. (Paulapuro 2000).

3.7 Folding box board

Demand of paperboard production continues to grow FBB can be considered the most important and one of largest paperboard group. Folding boxboard is widely used in many different packaging applications. Typical FFB packages are mainly used in food, cosmetics, alcohol, medicine and cigarettes and some species are also used for postcards and book covers. The main weighing area with FBB is 160 to 450 g / m^2 and it is typically made of three or in some cases from four layers. The backing and top layer is bleached with chemical pulp and middle layer is mechanical pulp (GW, PGW, TMP or CTMP). Middle layer is made from mechanical pulp due to its lower raw material costs and giving the bending stiffness as

a bulk property. Since most of the applications of folding boxboard are consumer packaging and are therefore printed, very much attention is paid to the appearance and characteristics of the top layer of the board as printing quality, high lightness and good grit ability i.e. clean joints at folding points. Therefore, the top surface can be coated one or two times depending on the application to ensure good appearance properties. The most important mechanical properties of folding boxboard are bending stiffness, smoothness, z-directional strength and thickness. (Paulapuro 2000; Karhu 2007 p.23). Typical structure of folding boxboard is showed in the below Fig. 5.

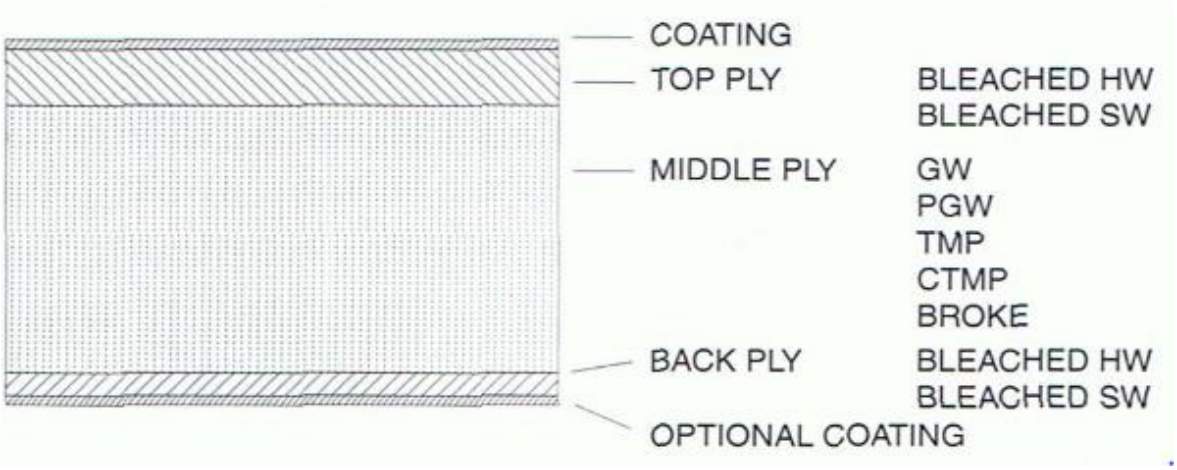


Figure 5. Folding boxboard structure (Paulapuro 2000)

3.8 NPD process

The product development process is a series of activities that the company implements to ideate, design and commercialize a new product. The product development process has been defined in several different ways, and perhaps one commonly presented in the literature is the six phases process step for systematic product development process as presented in Figure 1. The process begins with a planning phase and to the end production ramp up phase. According to Ulrich & Eppinger (2012 pp. 12-13) *''A product development process is the sequence of steps or activities that an enterprise employs to conceive, design, and commercialize a product. Many of these steps and activities are intellectual and organizational rather than physical. Some organizations define and follow a precise and detailed development process, while others may not even be able to describe their process. Furthermore, every organization employs a process at least slightly different from that of every other organization. In fact, the same enterprise may follow different processes for each of several different types of development projects'*

Nowadays, the product development process is a set of simultaneous and parallel processes that actively engage in discussion internally between different departments. Different angles such as marketing and production bring information to the process that otherwise could be left out of the way. (Trott, 2008, pp. 389-404)

Product development process can be divided into six phases, as shown in Figure 6. These phases are described in more detailed below.

Figure 6. The product development process based on Ulrich et al. (2012 p. 9)

Six phases of the generic development process start from the phase zero. Planning. It is the starting point of product development process where the target market for the product, business goals, key assumptions, and constraints are defined. (Ulrich et al. 2012 p.13)

In the concept development phase aims is to identify the target market objectives and at the same time create alternative product concepts for further development and testing.
The concept is a of the form, function and characteristics of the product, the purpose of which is to compare and can be analyzed for the competitors' products specification. There has been usually also an economic review carried out at this phase. (Ulrich et al. 2012 p.15)

Next phase is System-level design where the product entity is dismantled into smaller sub-assemblies and component levels. At this stage, preliminary design of key components is made, and final configuration design is also created. The result of this phase is the geometric product and functional specification it’s subsystem. (Ulrich et al. 2012 p.15)

Detailed design phase includes complete product specifications such as materials and tolerances in their parts. The process design and tooling design are created for each part of the product. The result of this phase is the project specification or drawings that describe the controlled plans for the product and the process. (Ulrich et al. 2012 p.15)

Testing and refinement involves the construction and evaluation of multiple pre-produced versions of the product prototypes are tested to determine whether the product will work as designed and whether the product satisfies the key customer needs. (Ulrich et al. 2012 p.15)

Final phase in the product development process in production ramp-up where the product is manufactured with the intended production system. Main purpose of ramp-up phase is to train workforce and eliminate any remaining problems in the production phase. (Ulrich et al. 2012 p.16)

According to Ulrich et al. (2012, pp. 12-13) a product development process can be useful when it contains below items:

• Quality assurance: A development process specifies the phases a development project will pass through and the checkpoints along the way. When these phases and checkpoints are chosen wisely, following the development process is one way of assuring the quality of the resulting product.

• Coordination: A clearly articulated development process acts as a master plan that defines the roles of each of the players on the development team. This plan informs the members of the team when their contributions will be needed and with whom they will need to exchange information and materials.

• Planning: A development process includes milestones corresponding to the completion of each phase. The timing of these milestones anchors the schedule of the overall development project.

• Management: A development process is a benchmark for assessing the performance of an ongoing development effort. By comparing the actual events to the established process, a manager can identify possible problem areas.

• Improvement: The careful documentation and ongoing review of an organization’s development process and its results may help to identify opportunities for improvement.

The product development process can be describing from three ways. The first way is to create initial set of alternative concepts and then narrow down this set by adding more detail specification of the product until it full will maturity reliability and repeatability manufacturing point of view. Second way is to develop an information-processing system. The process begins with the company's goals and strategic potential through available

technologies, product platform formats and production methods. Various process activities generate information, compiling specifications, concepts, and design points of view. The process will end after all communication and production information required for production support has been communicated. The third way is to develop the process is based on risk management system. In the early stages of product development, different risks are identified and prioritized. When the process progresses, the risks are decreased as the uncertainties are removed and the product is validated. When the process is completed, team has confidence that the product will work as it is designed and receive a good reception on the market. (Ulrich et al., 2012, p. 13)

There are many types of product development processes, and their utilization and use differ depending on whether designing products manufacturing company or a consumer in a commercial enterprise. In manufacturing industry, the life cycle of products is considerably longer than consumer products, but the current trend is in the direction of customers also requiring their convenience. This will give their own challenges to industrial companies in the future as they seek to improve their competitiveness and to target new markets. Depending on the industry sector, the slowdown in industrial product development may be affected by government regulation and internal obsolescence within industries. However, the integration of the customer into product development has also increased in the industry, and the important starting point for product development is thus more cost-effective, faster and the outcome is likely to result in less reclamation. (Trott, 2008, pp. 406-411)

3.9 Package NPD process

Quite limited number of publications for the packaging design development process are available. According to Bramklev, Bjärnemo, Jönson & Johnsson (2005 p.7) there is no generic procedure model for packaging development. Based on the literature review it should be noted that packaging design process follow very close relationship to specific product development process.

Publications from packaging development process are for example from authors Bramklev et al. (2005) and DeMaria (2000). DeMaria (2000) has described detailed step-by-step approach to the packaging development process, dividing it into three phases. Based on DeMaria packaging development procedure model consists three phases which are planning,

proving functionality and package launch. These main steps are divided more detailed process sub steps. Demaria packaging development process is described in Fig. 7 which consist of three phase which are planning, proving functionality and package launch. These phases including 12 different tasks during package development process.

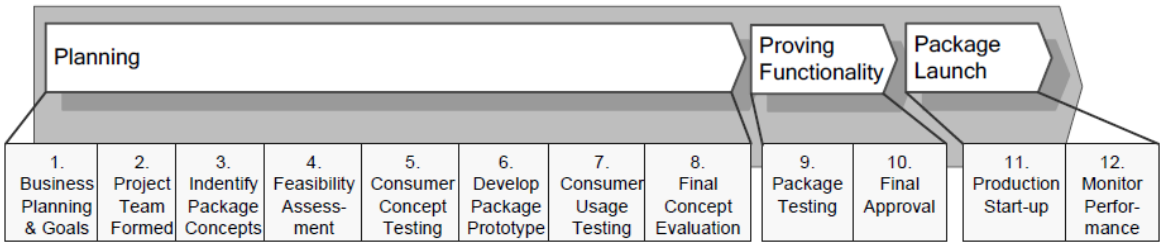


Figure 7. The Packaging Development Process (DeMaria 2000)

According to Bramklev et al. (2005 p.9) proposal of the packaging development process should be integrated with product development process. Proposed models different package activities are indicated by letter A-F in Fig. 8. This can affect logistics activities throughout the whole supply chain and it can be beneficial to considering new packaging design development.

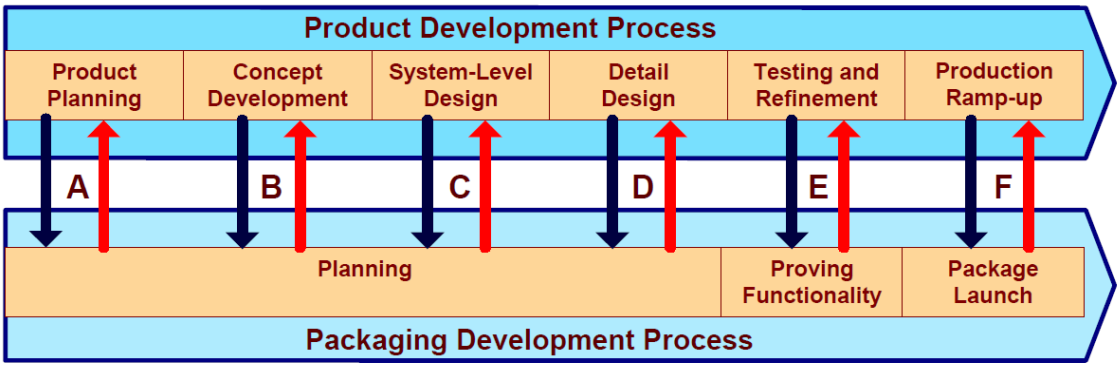


Figure 8. The packaging development process (Bramklev, 2005 p.9)

According to Bramklev et al. (2005 pp. 7-11). generic product development process model follows to the development process by Ulrich & Eppinger (2007). This process is widely known in industry and fulfill the needed requirements of the package development process. DeMaria (1990) process as a package development process has been chosen which best fit to generic process. Proposed model is illustrating the chosen procedure models which have

combined into one by connecting activities. These activities are indicated by letters A – F in Fig. 8.

3.10 Kano model

Customer satisfaction is very important for a company to be successfully leading. A satisfied customer often leads to loyal customers. These customers are also willing to pay more for quality of products and services. For this reason, considering customer satisfaction will help the company to gain market share in its market segment. By simply just only fulfilling customers' expectations of high product quality does not mean that customers are satisfied. (Matzler & Hinterhuber 1998 pp. 25-38)

One commonly used tool to understand customer preferences is Kano model. Professor Kano and his coworkers developed the Kano Model in 1984 in Japan. They were studying consumers purchase decision making process and contributing factors to customer satisfaction and customer loyalty. They classified 5 different categories of customer requirements, some which you wanted to have in product and which wanted to eliminate. (Kano model)

Main objective to use Kano Model is to help teams understand, classify and integrate these main categories and apply these requirements for products or services during product development process. Customer requirements categories are classified based on the how these contribute for the customer satisfaction or affecting dissatisfaction. When these main customer requirements are mapped later these help teams to prioritize importance of each requirements and which need to be included in final product or services. (Kano model).

The Kano model is presented in figure 9 where horizontal axis conveys how some aspects are implemented in the product, and the vertical axis indicates how well customer to be satisfied. (Berger, Blauth, Boger, Bolster, Burchill, DuMouchel, 1993 p. 3)

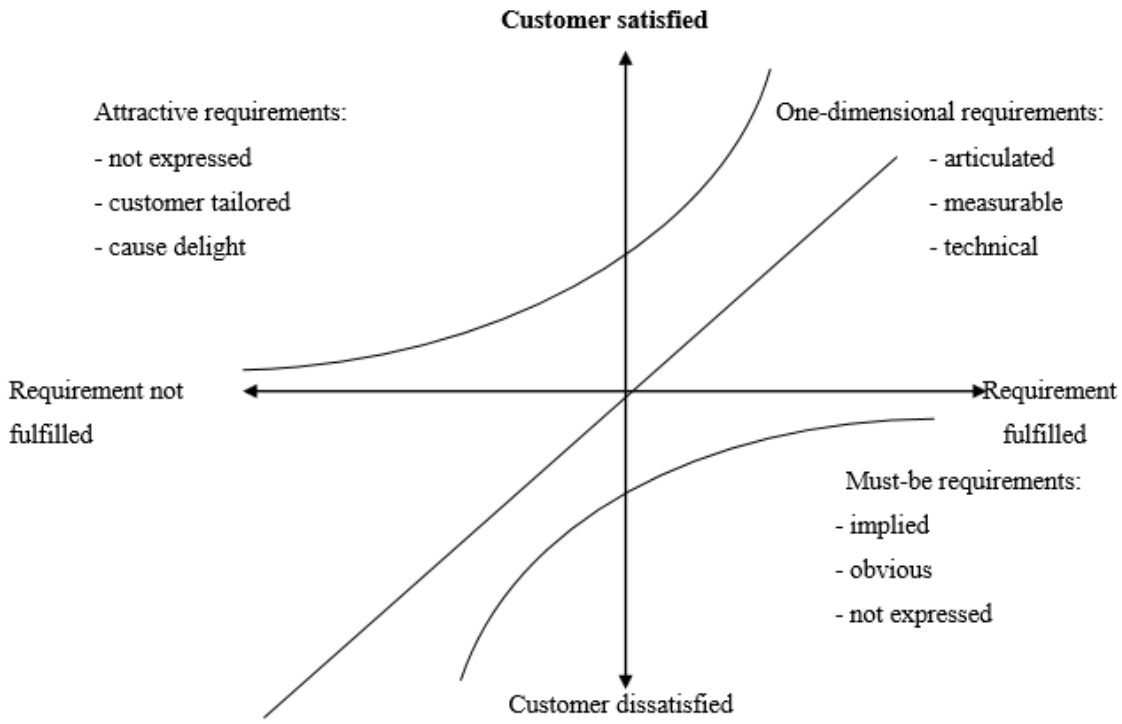


Figure 9. Kano's model of customer satisfaction (Berger et al. 1993 p. 3)

According the Kano model which is presented Fig. 9. there are three different product requirements which are affecting for customer satisfaction. These are One-dimensional, Must-be and Attractive requirements. One-dimensional requirements customer satisfaction is proportional to its level of satisfaction, how high the customer satisfaction level is the more satisfied the customer is. The Must-be requirements are the basic requirements that customers take for granted to be present in product and if they are not fulfilled then the customer be displeased and is not at all interested in the product. The Attractive requirements have the positive influence on the customers' satisfaction of the product because customers do not expect to have these requirements in products. The customer does not get unsatisfied if the product does not fulfill these requirements but if it is included that make customer's satisfaction is more than expected to have. (Matzler et al, 1998 pp. 25-38)

The Kano questionnaire contains pairs of customer requirement questions (Berger, et al., 1993 p.5) Each question has two parts: How do you feel if that feature is present in the product (functional form of the question) and how do you feel if that feature is not present in the product (dysfunctional form of the question) (Berger, et al., 1993 p.5). To each part of the question, the customer can answer choosing one of five alternatives. According to Berger

et al., (1993 p.14) the wording of the alternatives is the most critical choice made in the Kano methodology.

Kano Evaluation Table

Customer Requirements → / ↓		Dysfunctional 1. like	2. must-be	3. neutral	4. live with	5. dislike
Functional	1. like	Q	A	A	A	O
	2. must-be	R	I	I	I	M
	3. neutral	R	I	I	I	M
	4. live with	R	I	I	I	M
	5. dislike	R	R	R	R	Q

Customer Requirement is:

A: Attractive
M: Must-be
R: Reverse
O: One-dimensional
Q: Questionable result
I: Indifferent

Figure 10. Kano evaluation table (Berger et al., 1993 p. 29)

Each quality attributes can be classified by using Kano Evaluation table which is shown in Figure 10. Classification of attributes described previously it will made based on the pair question. Ranking has been chosen with Functional and Dysfunctional question. Ranking values can be later used as a weight coefficient in QFD House of Quality matrix. (Berger, et al., 1993 pp.10 -12 ; Kano, et al., 1984).

3.11 Quality Function Deployment (QFD)

One structured method that uses tools to identify and prioritize customers' expectations quickly and effectively is QFD (Quality Function Deployment). The QFD mythology originally started from Japan in the late 1960s, where it was developed by Professor Yoji Akao and Professor Shigeru Mizuno as a quality development system. Later this expanded to USA in the 1980's and it was introduced then also to the other western countries. The main idea was to implement products and services in a customer-oriented way, whereby the needs of end customers were considered at the early product development stage. The aim is to clarify the quality and customer satisfaction before the product or service is manufactured when it was previously done in the production or final product. The "voice of customer"

term describes this process, where (WHAT) are the customer requirements and (HOW) their technical requirements of the product or service. Customer needs are identified systematically and compared to the technical or functional characteristics of the product or service. Customer information can be collected many ways, such as interviews, surveys, target group analyzes, listening the sales people and industry reports. After the information is collected they are processed in QFD matrix which is the first part of the House of Quality system. (Akao et.al, 2003, pp. 20-31; Francis, 2016, pp 65-70; Mehrjerdi, 2010, p. 617)

Typically, QFD system consists of four parts of House of Quality matrix that are used in the product development process. At each step, one or more matrices are made to assist the design process and communication. Akao and Mizuno developed these tools and techniques together with other Japanese quality managers. Statistical quality control was introduced in Japan after the Second World War and become more common in Japanese manufacturing companies and understood the importance of quality throughout the product development and manufacturing process. (Akao et.al., 2003, pp. 20-31)

The QFD method was first introduced shipbuilding and electronic industries even it was originally designed for the automotive industry. Today, QFD is used not only in physical products, but also in the development of services, and its use has spread widely different industries around the world. The use of the QFD method can be expected to increase in the future as well, especially when it comes to developing new products on the market and to better cooperate with customers. (Akao et.al., 2003, pp. 20-31; Mehrjerdi, 2010, p. 632)

House of Quality diagram is presented in Fig. 11 Starting point is to list identified customer needs and benefits to the customer requirements column. When customer requirements are inserted to the matrix left side house diagram next step is to evaluate and give weighting to these requirements. Technical characteristics are the features that organization will respond for the customer requirements. This may include example power, strength or other technical features which wanted to include in product. As showed in Fig. 10. the central of the House of Quality is the relationship matrix where customer need matched against each technical characteristic. Each characteristic will have weighted (typically 0, 1, 3, 9) in their own column on the central. (Bicheno & Holweg 2009 pp.239 – 243)

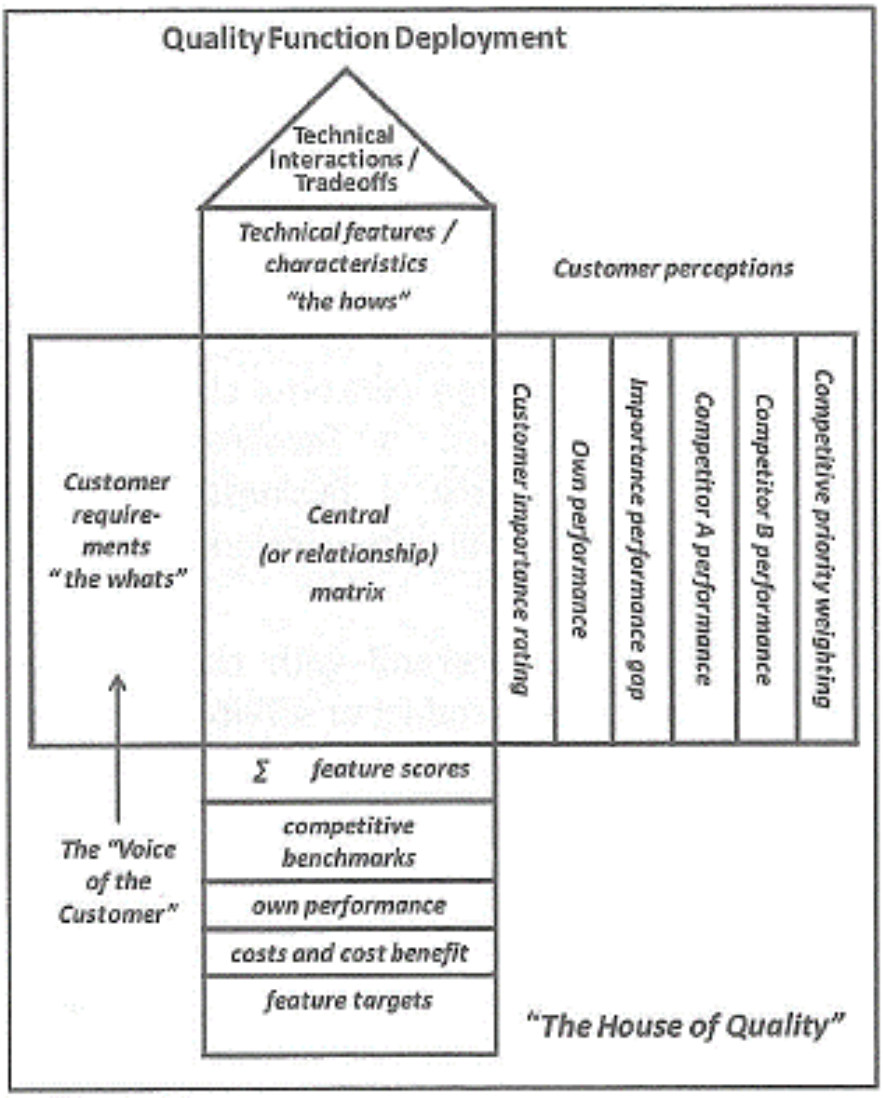


Figure 11. House of Quality matrix (Bicheno et al, 2009 p.240)

QFD process requires expertise to develop the HOC matrix and there are also some limitations of its use like not practical personnel taking part of QFD process. Because of the complex process many company have implemented QFD only to partial extend. One of the main strengths of QFD is its ability to support teamwork / spirit, motivation and communication between people involved in product development process. Without a common passage of a QFD process, a common discussion of goals and engagement with tasks in planning may be lacking. For example, each personnel's tries to develop the product according to his / her own goals. (Devadasan et al., 2006, p. 144-160). According to Bicheno et al. (2009 p. 240) main advantage of QFD it uses multidisciplinary team as a marketing,

design, engineering, manufacturing, distribution and other departments to works together simultaneous engineering approach.

With QFD, high customer satisfaction is achieved by products because customer needs are bringing part of the product development process from the start. Customer satisfaction is increased so this mean that reclamations are reduced when product is better responsive to customer requirements. Consequently, even totally unsuccessful products or services do not end up in production and the market. This is particularly important fast-moving consumer goods when the product life cycle is shortened and must remain in market competition. QFD can also helping decision making relating the customer requirements when launching a new product or is company even able to produce this kind of product. As a common thing QFD improve the effective communications between the different stakeholders and providing sufficient documentation for important information. (Mehrjerdi, 2010, p. 632)

According to Cristiano, Liker & White (2001 pp. 81-95) implementing QFD method to the product development process many significant improvements in product design and process. Main benefits are reduced product redesigning, issues in early phase during production launch, better product quality and increased customer satisfaction. Fig. 12 illustrates effect when implementing QFD process is reported to shorten product design and development lead time. QFD also offers to the company the opportunity to bring customer-oriented, high quality products to the market faster.

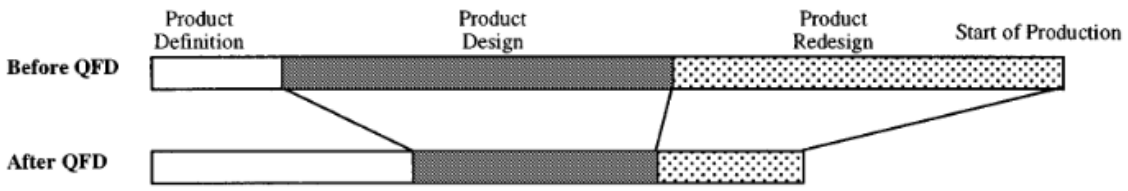


Figure 12. QFD's effect on product development lead time (Cristiano et al. 2001 p. 82)

3.12 DFMEA

DFMEA (Design Failure Mode and Effect Analysis) is a methodical approach to review design product and processes where identifying potential risk both design and manufacturing quality objectives to meet customer requirements. The DFMEA method initially identify

function of design, failure modes and their effects to avoid as many potential failures as possible. By identifying the potential risks and taking relevant actions at all stages of product development, the tool's results can be utilized in design changes and process improvements that can reduce potential risk or failure mode. This method can be used in all stages of a product's life cycle. (Zheng, Liu & McMahon 2010 pp.1-2)

Component	Component Function/ Require-ments	Potential Failure Mode	Potential Effect(s) of Failure	S e v	C l a s s	Potential Causes(s)/ Mechanism(s) of Failure	O c c u r	Current Process Controls - Prevention - Detection	D e t e c	R. P. N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
													Actions Taken	S e v	O c c	D e t	R. P. N.
										0							
										0							
										0							
										0							

Figure 13. DFMEA model

Fig. 13 above illustrated one template of the DFMEA model and its failure modes and their potential effects on the customer. According Bluvband & Grabov (2009 p. 344) ‘’the Failure Mode and Effect Analysis is a proactive tool developed to identify, evaluate and prevent product and/or process failures’’. Also stating that the effectiveness of the DFMEA can be significantly improved by raising awareness of potential problems and bringing these out by using this tool.

DFMEA classify risk and team ranks the Severity (S) of the failure, the probability of its Occurrence (0) and the probability of detecting the failure mode or its cause, Detectability (D). RPN (Risk Priority Number) is calculated by multiplying the ranking values of Severity, Occurrence and Detectability and this total number shows the risk assessment. This categorization total score for each possible cause of each failure using the following equation: $RPN = S * O * D$. (Bluvband et al., 2009 pp. 344-345)

The study of FMEA based packaging improvement case by Liu, Cheng, Lee & Gau. (2015 pp. 413-431) how to find critical failure factors for the best product design during the NPD phase. Research show how improvement and preventions are conducted via FMEA. According the study customer requirements together with integrated QFD procedural methods for the product development shows that the key factors of product design can be practically planned and preventive possible losses and failures in field by using FMEA.

According the Sorli & Dragan (2009 p.28) ‘’The FMEA is, in a nutshell, a documented summary of the thought process that takes place in the mind of the engineer or designer of the product or process being developed or manufactured. Naturally, it is based on the designers’ experience and on the accumulated knowledge on past problems. It is a systematic approach that formalizes the mental discipline that the best designers always apply´´.

3.13 Consumer package tests

There are many types of requirements on packaging and their functionality, and they also make it necessary to test packaging. When planning package tests there is several questions where trying to answer example; The test is intended to validate the functionality of the planned things, such as what the main purpose of this test, how to test and how the results are used inside of company. In addition, well-designed tests produce results that are applicable to the initial purpose and can be used later. (Järvi-Kääriäinen, 2007 pp. 292-297)

Packages have lot of test method available based on standard and some of the most common test methods for packaging testing are example strength, friction, tear, compression, lamination / bonding and puncture strength tests. (ASTM 2018)

There are some actors available which provide common package testing standards that can be used as a preliminary verification method in packaging development. One commonly used standards which are widely used in industry are ISTA (International Safe Transit Association) or ASTM Standards for Package Testing. (ISTA 2018; ASTM 2018)

3.14 Transportation package

The purpose of transport packaging is to protect the products. Fiskars require transportation boxes, retail and master (RBX and MBX) to always be strong enough to withstand impacts and rough handling on its journey to market. This includes the whole supply chain from vendor via Fiskars DC to end customer. It is especially important that fragile products are packed in strong enough boxes. This case study focus is only consumer package but also some testing are needs for RBX and MBX packages during development phase.

Transportation test in this case are related to RBX and MBX packages. (Fiskars General Transport Packaging Guideline 2013)

4 RESULTS

This chapter explains how the Kano, QFD and FMEA analyzes were conducted within the NPD process during 2018 and what kind of results were obtained from the analysis. Consumer study results are the base of this chapter.

4.1 Packaging development process

Referring to the overall objective in this case, a generic product development process model has been described because of company confidential material not wanted to be published in detailed level. Package development activities in this study is referred to the generic product development process based on Ulrich & Eppinger (2012 pp. 12-15). None of the organizations follow an identical NPD procedure as shown earlier, however when analyzing the findings into theory those process phase activities are very similar.

Figure 14. VoC study during NPD process

Planning is the starting point of the product development process where the target market for the product, business goals, key assumptions, and constraints are defined. In the concept development phase the idea is to identify the target market objectives and at the same time create several concepts for further development and testing. Package activities started in the VoC study which has been carried out during concept development phase Fig. 14. Package main characteristics have been checked in target market consumer survey. Voice of customer results are presented in the Kano model.

4.2 Data collection for Kano model

Data collection conducted in the beginning of 2018 in Finland on how customers perceive packages when they are making a purchase decision. A survey on watering category buying behavior was sent to Fiskars internal focus group register. At the end of the survey the

respondents were asked if they would be willing to participate in an interview or focus group on the subject.

The survey got totally 37 responses 17 respondents said that they would be willing to participate in further interview or focus group. Invitation to the focus group was sent to those 17 people and 9 people participated in the focus group.

The aim of the focus group was to find out:

- What, if anything, makes buying connectors and watering equipment difficult.
- Does the Fiskars packaging solution help the consumers find the correct product easier than from other manufacturers?
- Are people willing to buy connectors from a different brand to the one they have at home?
- Which of the Fiskars packaging options is the best in consumers' minds?

To get an understanding of the selection process in the store, a mock-up store shelf was built with other manufactured products beside Fiskars products. Mock up store shelf is shown in Fig. 15 where the all Fiskars connectors and watering items are presented.

The participants were taken to the shelf in groups of three. Each were given a task to buy either:

1. Quick connector to the hose they have at home. The hose diameter is 13 mm.
2. Hose repair connector to the hose they have at home. *They were shown a sample of the hose prior to going to the shelf.*
3. Tap connector to the hose they have at home. *They were shown the tap prior to going to the shelf.*

Figure 15. Fiskars mock-up store shelf during survey

Fiskars mock-up store is shown in Fig. 15. Consumers must select the right connector from the rack according to the task which has been given.

Main outcome from the result was that:

- Cheerful color and the large and easy to understand images of the other brand packages draw in the potential buyers and help them find the correct product. Pictogram version is much clearer than only the picture, you can clearly see for what usage the product is meant. The pictogram version shown in Fig. 16 has been selected as best in survey.

Figure 16. Different package card in visual survey

- Black Fiskars products against black cards make identifying the products more difficult
- The participants relied on the texts on the packages, not the images
    - The image on the Fiskars package is too small, you can't see it or use it to identify the usage of the connector
    - The texts are clear but only English texts may not be enough and local language is missing
- Fiskars advantage is that the products are not in plastic cover, you can touch them and open the connectors to see inside
- Less packaging material is also more ecological

4.3 Kano and QFD results

QFD process-initiated Concept development phase where the package entity is dismantled into smaller design features from the customer survey. At this stage, main design characteristics as a form, function of the package has been defined and can be also analyzed for the competitors' specification. House of Quality 1 (HOC1) where customer needs are translated into technical design requirements activities has been done in concept development phase as Fig. 17.

Figure 17. QFD House of Quality 1

Main requirements on the package in these case projects were that all packages must meet the criteria defined in the Fiskars General Requirements for Packaging Design. Also, consumer validation was needed to ensure that the Fiskars packages help make the selection of the correct product easy. QFD process House of Quality I part products engineering characteristics can be transformed via discussions by team members of the task force on customer requirements. Main requirements are listed below and used further in Kano & QFD evaluation tools based on the consumer feedback study on this case.

Package requirements taken from the survey:

- The product can be tested on the packaging
- Package should have enough room for the necessary information. The information on the package should be visible and clear.
- The packages should be egologic. Minimize waste and material use.
- The packages should be durable and endure handling
- The packages should be suitable for logistic efficiency
- The packages should protect products
- The packages should be efficiently packed in point of sale locations

Requirements based on internal Packaging guideline:

- Legal requirements
- Markings
- Labeling of retail and master boxes
- Logistics information and DC requirements.

4.4 Analysis of Kano and QFD result

In this study we only focus on case specific requirements which are taken from the survey in the Kano evaluation table. Importance numbers and relationship numbers are shown in QFD House of Quality matrix 1 in Fig. 18.

Attractive quality attributes provide satisfaction when achieved fully but do not cause dissatisfaction when not fulfilled. These quality attributes are product try feature in package and ecology. These types of quality attributes often unexpectedly delight customers, they are just as often unspoken properties because consumers don’t expect such a quality property of a product.

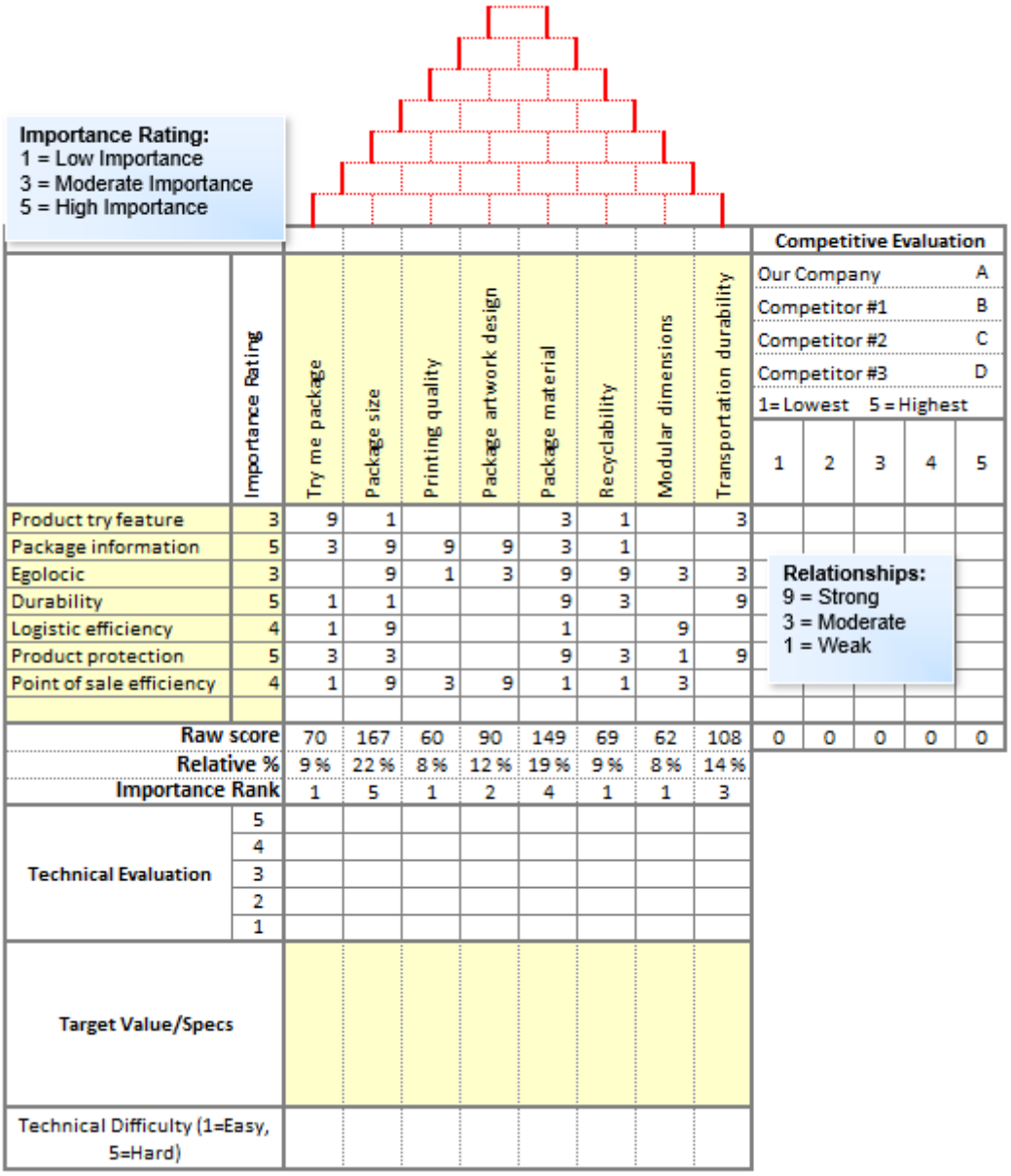
One-dimensional quality attributes result in satisfaction when fulfilled and result in dissatisfaction when not fulfilled. Refer to one-dimensional quality attributes as the-more-the-better attributes, i.e., the more of it there is, the better and the customer likes it. One-dimensional attributes in these packages are point of sales and logistic efficiency. An

example if package have optimized use of space, shelf ready properties and which are easy to handle by customers.

Must-be quality attributes are taken for granted when fulfilled but result in dissatisfaction when not fulfilled and these are kind of generic that customers expect that these properties are already built in packages. In this case example package information, durability and product protections are must be attributes. Customers are dissatisfied when the product information does not meet the consumer expectations, but when information in packages is fulfilled the result is not increased customer satisfaction. Since the customer expects these attributes and views them as basics features and they assume that companies understand that these are product design fundamentals.

A triangular-shaped matrix placed over the customer requirements and engineering design requirements corresponds to the correlations between them. On the left side are the identified customer requirements and vertical columns are the identified engineering design requirements known as “what’s” and “how’s”, respectively. Relationship matrix between what’s and how’s is ranked by numbers 9, 3 or 1. If there is no relationship with customer requirements and engineering design requirements these can be blank.

Importance rating are evaluated by using Kano evaluation table which presented literature review Fig. 10. Package information, Durability and product protection has been evaluated as importance number 5 which are the must be attributes. Same logic has been used for rest requirements and these get either number 4 or 3 for importance ratings.



Importance Rating:
1 = Low Importance
3 = Moderate Importance
5 = High Importance

	Importance Rating	Try me package	Package size	Printing quality	Package artwork design	Package material	Recyclability	Modular dimensions	Transportation durability
Product try feature	3	9	1			3	1		3
Package information	5	3	9	9	9	3	1		
Egolocic	3		9	1	3	9	9	3	3
Durability	5	1	1			9	3		9
Logistic efficiency	4	1	9			1		9	
Product protection	5	3	3			9	3	1	9
Point of sale efficiency	4	1	9	3	9	1	1	3	
Raw score		70	167	60	90	149	69	62	108
Relative %		9 %	22 %	8 %	12 %	19 %	9 %	8 %	14 %
Importance Rank		1	5	1	2	4	1	1	3
Technical Evaluation	5								
	4								
	3								
	2								
	1								
Target Value/Specs									
Technical Difficulty (1=Easy, 5=Hard)									

Competitive Evaluation

Our Company	A
Competitor #1	B
Competitor #2	C
Competitor #3	D

1= Lowest 5 = Highest

1	2	3	4	5
0	0	0	0	0

Relationships:
9 = Strong
3 = Moderate
1 = Weak

Figure 18. House of Quality 1

4.5 Pareto diagram of result

Pareto diagrams are used, for example, for the classification and arrangement of identified problems based on a selected quantity. Features are presented in the bar graph in order of magnitude. This allows visually to be easily identified as the major cause of the problem and can be used to eliminate them. Simplicity in the Pareto chart makes it very effective. For example, continuous improvement Pareto analysis should be used to identify the main issues in the analysis and prioritization them. (Liker, 2013, p. 255)

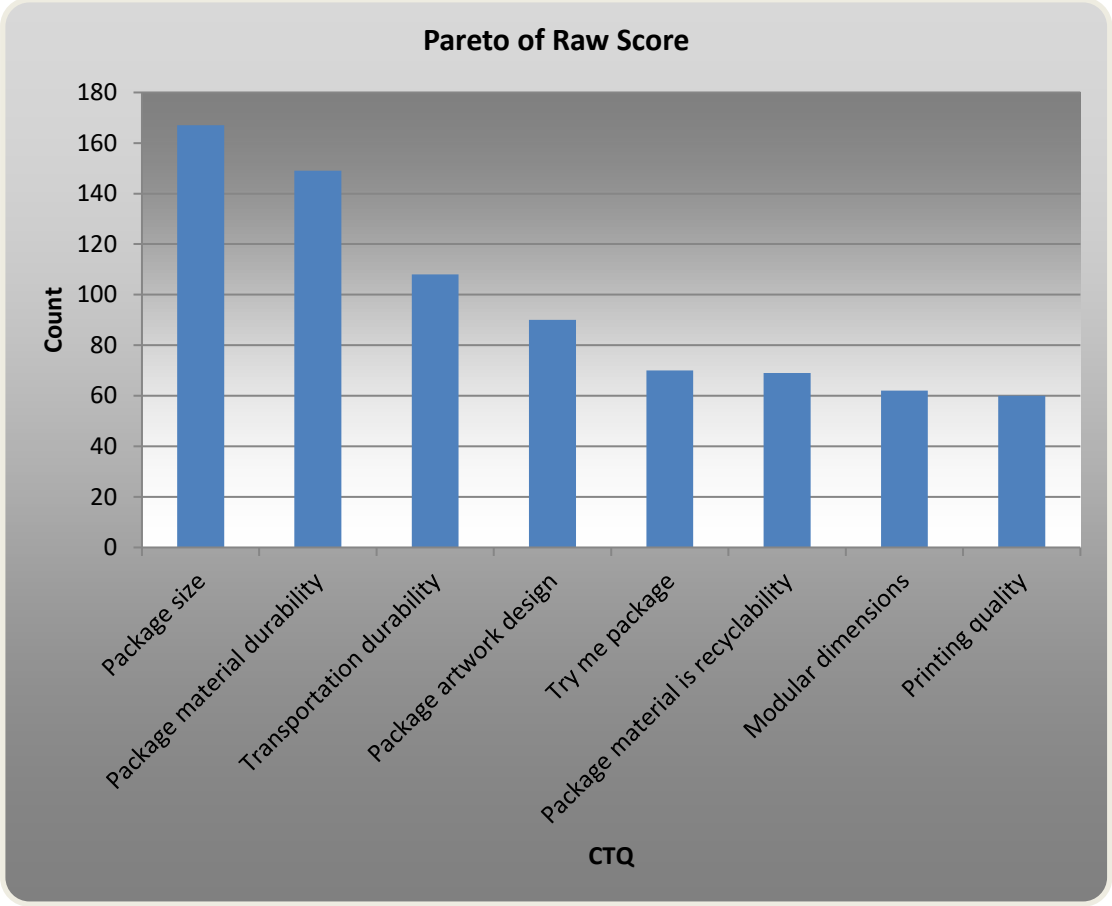


Figure 19. Pareto analysis for VoC requirements

Pareto chart is generated from QFD I package features (HOW) results. Based on the Pareto charts which showed in Fig. 19 the most important metrics for package development are package size, material, artwork design and transportation durability. At least these metrics should be considered when developing the packaging key characteristics.

Package Size and material durability:

The packaging materials and size characteristics means that package is designed way that it is suitable in consumer / customer and handling, storage and transport conditions. According the Fiskars Internal packaging guideline (2013) the size and mass of the packaging should be minimized when designing and manufacturing the package. It should be ensured that the weight and/or volume of the packaging material is minimized but still meets the requirements set by:

• Functionality throughout the supply and user chain

• Safety and hygiene for both product and user/consumer

• Acceptability of the packed product to the user/consumer

If a package is claimed to be reusable, the package should endure several usage cycles when used in normal conditions, as defined in the standard.

Transportation durability:

The transport package must be effective and efficient in the supply chain and pass specific transportation tests. Transportation affects can be big for the packaging design if this not considered. The choice of material is also influenced by the way how packages are going to be delivered to the consumer. It can be done example on land, sea, air or somewhere in these combinations. The package material must also withstand the work done by the workers without breaking and the color wear on the packaging. (Fiskars Internal packaging guideline 2013)

Package artwork design:

Package artwork design characteristic is more related the visual appearance and package communication. Artwork design makes the product attractive to the consumer, providing needed information about the product. Own symbolic will be used communicating product functions and inside of packaging cards more specific information will be given with different languages. Product package artwork card is shown in the below Fig. 20. Front face of package shows the product and which kind of purpose product to be used. Back side of package card have a bar code whence package can be read in shop and name of the product with different languages. Center spread of package card inform more how to use product.

Figure 20. Package card information in case project

Regarding to the consumer packaging, the law states that they must have a certain amount of information about the packaging and its purpose of use. The high quality and uniform appearance of cardboard improves printability and packaging communication to consumers.

4.6 House of Quality II

After customer requirements are considered in package development process next step is in QFD process carry out House of Quality II. House of quality II matrix cross functional team is focusing how critical customer requirements are measured or how those to be verified / measured during NPD. The working assumption was that a translation from customer needs to be set of precise, measurable specification which can be verified internal test lab.

HoQ II matrix has been done System level design development phase where the package preliminary design is made, and final configuration design is also created. House of Quality II where main design characteristics has been done is shown product development process phase as Fig. 21.

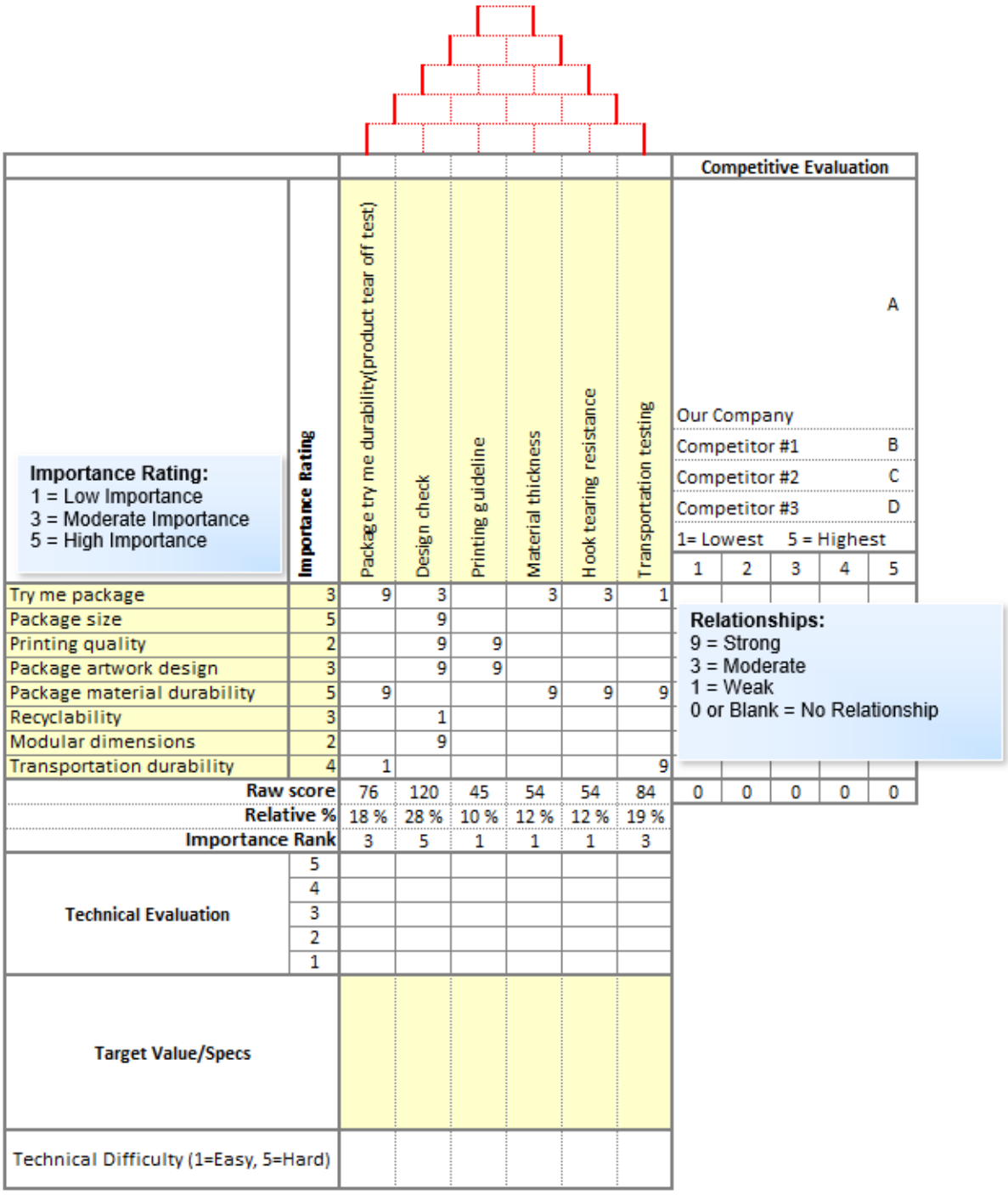
Figure 21. HoC II during NPD process

Main package design characteristics are:

- Try me package
  - ➢ Product can be felt and touched in packages
- Package size
  - ➢ The size and mass of the packaging should be minimized when designing and manufacturing the package. It should be ensured that the weight and/or volume of the packaging material is minimized but still meets the requirements
- Printing quality
  - ➢ According to the artwork specification: Clean, neat, dry, not stained, not broken or smashed
- Package artwork design
  - ➢ Package must match the artwork file

- Package material durability
  - Functionality throughout the supply and user chain must work
- Recyclability
  - All materials used for packaging purposes should be recyclable ad to comply with the EU packaging directive 94/62/EC
- Modular dimensions
  - Comply with modular dimensions. The size and mass of the packaging should be minimized
- Transportation durability
  - According to Fiskars Transport packaging guideline

House of Quality II evaluated same way than HOQ 1 earlier through the Kano evaluation table. Package size and package material durability importance rated for 5 which are so called must be quality. Transportation durability importance is rated for 4 when prioritized the main package features by using Kano evaluation table. Transportation durability importance rated for 4. Printing quality, modular dimensions, recyclability, try me package and package artwork design are either one-dimensional or attractive quality in Kano evaluation table. HOQ II matrix is presented in Fig. 22 where the importance and relationships numbers are ranked for each ‘’what’s’’ and ‘’how’s’’ in HOQ II matrix.



								Competitive Evaluation				
Importance Rating: 1 = Low Importance 3 = Moderate Importance 5 = High Importance	**Importance Rating**	Package try me durability(product tear off test)	Design check	Printing guideline	Material thickness	Hook tearing resistance	Transportation testing	A Our Company Competitor #1 B Competitor #2 C Competitor #3 D 1= Lowest 5 = Highest				
								1	2	3	4	5
Try me package	3	9	3		3	3	1					
Package size	5		9									
Printing quality	2		9	9								
Package artwork design	3		9	9								
Package material durability	5	9			9	9	9					
Recyclability	3		1									
Modular dimensions	2		9									
Transportation durability	4	1					9					
Raw score		76	120	45	54	54	84	0	0	0	0	0
Relative %		18 %	28 %	10 %	12 %	12 %	19 %					
Importance Rank		3	5	1	1	1	3					
Technical Evaluation	5											
	4											
	3											
	2											
	1											
Target Value/Specs												
Technical Difficulty (1=Easy, 5=Hard)												

Relationships:
9 = Strong
3 = Moderate
1 = Weak
0 or Blank = No Relationship

Figure 22. House of Quality II

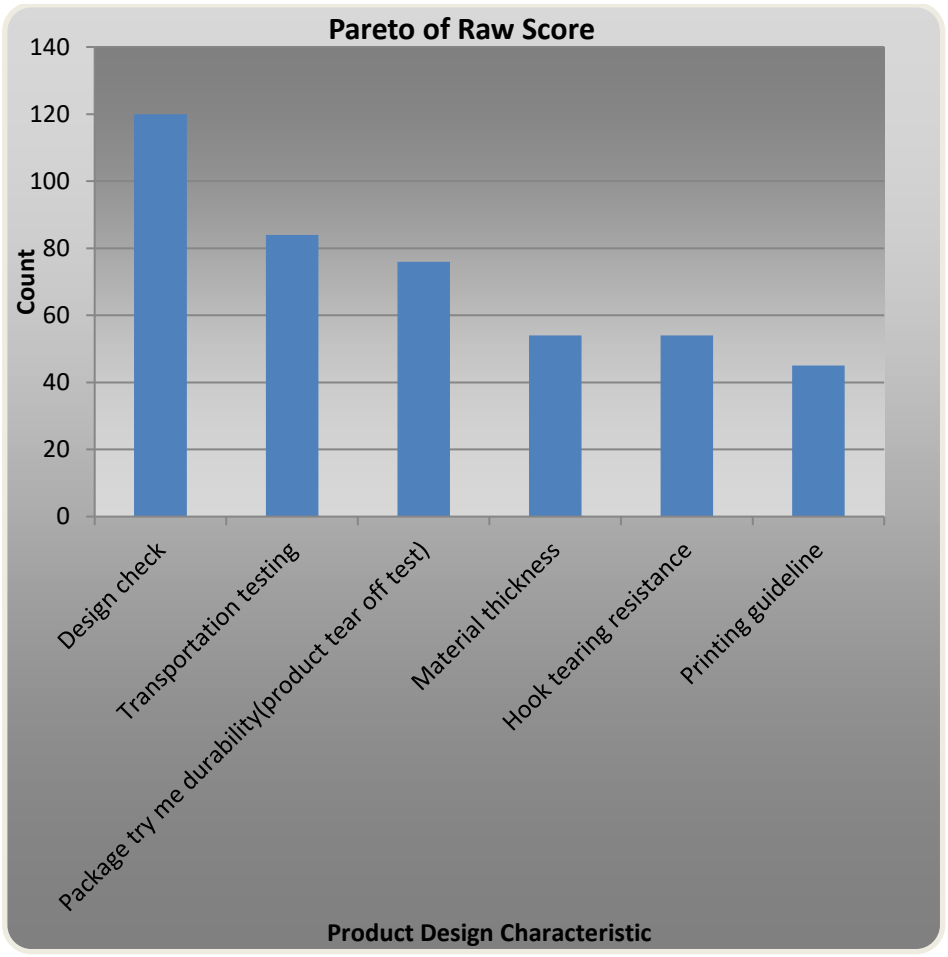


Figure 23. Pareto analysis from HOQ II matrix

Above Fig. 23 Pareto analysis shows from HOQ II matrix priority order of main design characteristics which need to be verified during NPD. Characteristics are described below:

- Design check

Key parameters in this case are main dimensions of the package drawing and needed amount is fitting correctly to the RBX (RBX effectiveness). Design check validation has been done as a defined to check product try me feature properties, product does not cover package text, package color and dimensions are according the specification.

- Transportation testing

According internal transportation guideline either standard ISTA transportation tests or case selected method to check transportation durability.

- Package try me durability (product tear of test)

Test method is described in “Internal test method, Appendix 1”. This test is ordered to show how well the product stays on the packaging card when a product is tried by the customers action. Tear of test is presented in below Fig 24. The product is mounted to the package card with a cable tie and this test simulates in which force the package starts tearing.

Figure 24. Product tear of test

- Material thickness

Material and thickness are as specified in the 2D drawing. The package must match the specification which is shown in below Fig. 25.

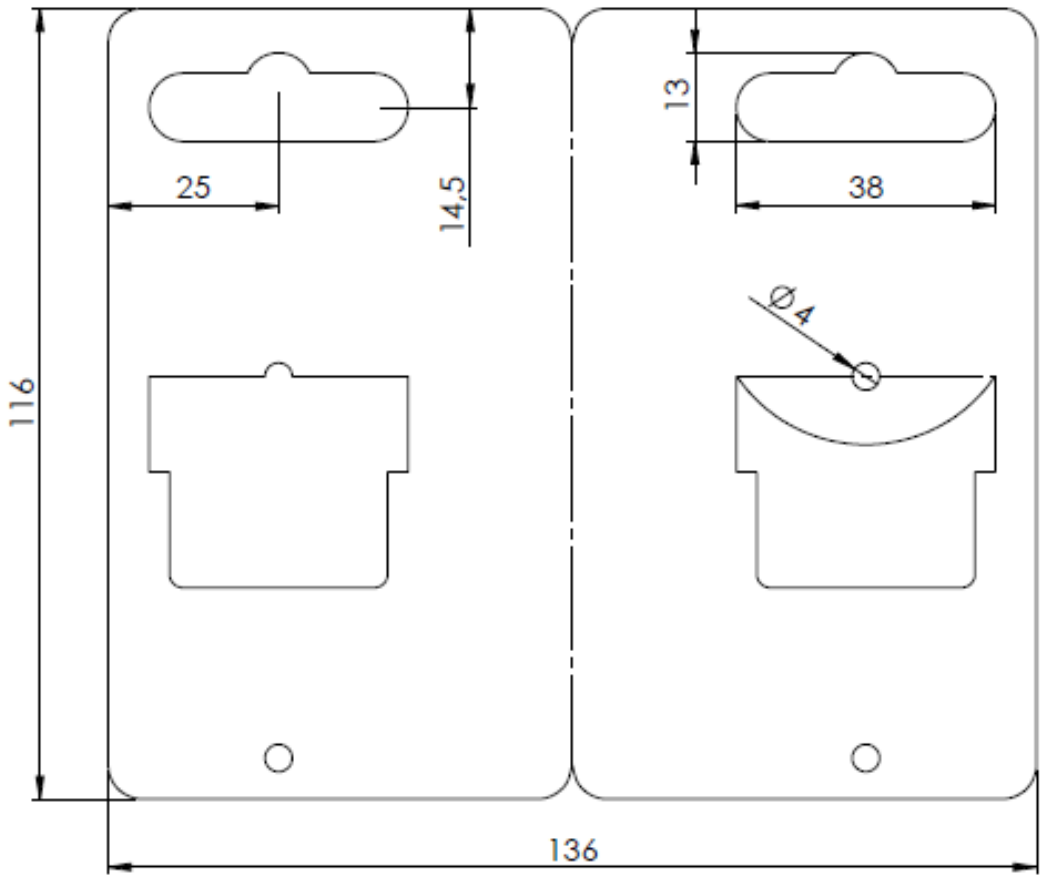


Figure 25. Case project package 2D drawing.

Paperboard material is specified FBB 350G. According the Iggesund (2018) paperboard grades DIN 19303 standards define that Folding Box Board can be coated GC1 or GC2 types. Different paperboard grades are classified in Fig. 26

Abbreviations/keys			
According to DIN 19303			
GZ	**Coated SBB**	**SBB**	**Solid Bleached Board**
AZ	Cast Coated SBB	**FBB**	**Folding Box Board**
GC1	**Coated FBB, white back**	SUB	Solid Unbleached Board
GC2	**Coated FBB, cream back**	WLC	White Lined Chipboard
GN	Coated SUB, white or brown back	G	Gestrichen, coated
GT	Coated WLC, cream or white back	U	Ungestrichen, uncoated
GD1	Coated WLC, grey back (spec.volume <1.45 cm³/g)	A	Gussgestrichen, cast coated
GD2	Coated WLC, grey back (spec.volume 1.3 to 1.45 cm³/g)	Z	Chemisch gebleichte Frischfasern, bleached virgin chemical pulp
GD3	Coated WLC, grey back (spec.volume <1.3 cm³/g)	C	Holzstoff, virgin mechnical pulp
UZ	Uncoated SBB	N	Chemisch ungebleichte Frischfasern, unbleached virgin chemical pulp
UC1	Uncoated FBB, white back	T	Rezyklierter mit weisser oder gelber Rückseite, recycled with white or cream back
UC2	Uncoated FBB, cream back	D	Rezyklierter mit grauer Rückseite, recycled with grey back
UT	Uncoated WLC, cream or white back		
UD	Uncoated WLC, grey back		

Figure 26. Paperboard grades (Iggesund, 2018)

Hook tearing resistance

Test method is described in “Internal test method, Appendix 2”. This test is ordered to show what is the limit when product is torn from the hook. Standard Euro hole fixture must be fit to the package card. Fig. 27 below shows the test method.

Figure 27. Hook tearing resistance test.

- Printing guideline

Package printing must match to the specification

4.7 DFMEA

After the QFD the process team should consider possible risks by using the DFMEA method to initially identify function of design, failure modes and their effects to avoid as many potential failures as possible from the customer point of view. Package development DFMEA is conducted during NPD process as a System level design development phase by identifying the potential risks and taking relevant actions into account. Main results from the tools can be utilized in design changes and process improvements that can reduce potential risk or failure modes in later phase.

The results of DFMEA analysis are listed in below Fig 28. In this case high probability causes were not found and the team thought this to be because of this case package was a simple card. Biggest RPN value was related the package information, if product is mixed to another type of connector. This was recommended to check specifically in Fiskars Inspection Check (FIC) before each shipment.

FAILURE MODE AND EFFECTS ANALYSIS
(FMEA)

Supplier name		**Fiskars Su**	**Prepared by**							**Issue date**		**Revision date**					
Supplier information		Supplier add								4.6.2018		YYYY-MM-DD					
Material code			**Core team**							**Process Responsibility (if applicable)**							
Inquiry reference			M. Onnela, M. Haltunen														
Material Name / Description			**Approved by (name & contact information**							**Approval date**							
Material code:										YYYY-MM-DD							
Component	**Component Function/ Require-ments**	**Potential Failure Mode**	**Potential Effect(s) of Failure**	**Sev**	**Class**	**Potential Causes(s)/ Mechanism(s) of Failure**	**Occur**	**Current Process Controls – Prevention – Detection**	**Detec**	**R.P.N.**	**Recommended Action(s)**	**Responsibility & Target Completion Date**	**Action Results**				
													Actions Taken	**Sev**	**Occ**	**Det**	**R.P.N.**
Package card	**Protection**	Transportation damage	Visual damage	3		Retail box material / design	3	Transportation testing	2	**18**	Transportation test during NPD						
	**Point of sales**	Card Tearing	Hanging hook failure	8		Material	3	Hook tearing test	2	**48**	Hook tearing test during NPD						
	Information	Wrong information	Wrong package card	8		Assembly work instructions	2		4	**64**	To be checked in FIC						
		Wrong information	Wrong EAN Code	8		Artwork failure	2		5	**80**	To be hecked in FIC						
		EAN code quality	Can not identify package card	6		Printing / artwork failure	2		5	**60**	To be checked in FIC						
		Package color defect	UV	6		UV protection	2		2	**24**	To be checked in FIC						
	Product Assembly	Assembly error	Product drop from package	6		Insufficient assembly	2		5	**60**	Assembly instructions						
										0							
										0							

Figure 28. FMEA analysis for package card

The effects of a failure on multiple customers are listed in this column. Many effects could be possible for any one failure mode. All effects should appear in the same cell or grouped next to the corresponding failure mode.

Team will give specific numbers for Severity, Occurrence and Detection. When those numbers are multiplied together R.P.N severity of possible failure mode has been evaluated. Approach has been selected in this case that if R.P.N number is 100 responsible persons should take an action for the failure mode. Evaluation criteria and typical rankings has been described in below.

4.7.1 Severity

The Severity of each effect is selected based on the impact or danger to the end user / customer. DFMEA severity ranking numbers are typically between 1 through 10.

Severity description for each number are:

10) Security risk without warning
9) Security risk with warning
8) Loss of primary function
7) Reduced primary functionality
6) Loss of secondary function
5) Reduced secondary functionality
4) Minor defects, discovered by most customers
3) Minor defects, discovered by some customers
2) Minor defects, discovered by sensitive customers
1) No visible effect

Team will consider the highest severity for each potential effect and giving number to the Severity column.

4.7.2 Occurrence

The Occurrence ranking is an estimate based on known or lack of data. Occurrence Rankings follow the logic below:

Probability of occurrence

9-10) Very high: Persistent failure

7-8) High: Frequent failure

4-6) Medium: Occasional failures

2-3) Low: Few failures

1) Very low: Failure is unlikely

4.7.3 Detection

Detection Rankings are assigned to each failure mode based on the likelihood technique.

Typical Detection Rankings are:

Likelihood of detection

10) Absolutely uncertain, can't detect

9) Very low chance to detect

7-8) A low chance to detect

5-6) A medium chance to detect

3-4) A high chance to detect

2) A very high chance to detect

1) Almost certain to detect

4.7.4 Recommended actions and responsibility

The actions are placed in the Recommended Actions Column. It is necessary to comment that column when and how possible failure to be checked during NPD. For responsibility column can added dedicated person during NPD in subject area.

4.8 Failure modes in this case

Possible failure modes are identified for customer viewpoint in DFMEA template Fig. 27. During transportation, possible failure mode is that product or package cards are damaged in retail box. Card is warped, or some printings are worn out and which will lead some

unsatisfied customers. This will be verified during NPD specific transportation test and possible failure modes to be checked.

Wrong package information failure modes might be related in case if wrong package has been used for products. In this case example 13mm quick connector there is possibility to mix either stop connector or flow connector. Wrong EAN / Bar code is one possible potential failure mode because of products can be mixed with another type. EAN-code quality issues is related when code cannot been read with barcode reader and it should be labelled in accordance with the GS1 standard. Potential package color defects are related UV specific failures if colors are not according the specification. All these potential package information issues to be checked specific Fiskars Inspection Check (FIC) before shipment leaves from suppliers.

Last possible failure mode is if product drop from the package card. This might happen if cable tie is loose and not properly tightening at assembly line. Recommended action for this failure is to create sufficient package work instructions and operators training to avoid this issue.

According the Case project DFMEA results which are shown in Fig. 27 team got information possible failure modes and effects. Based on Fig. 27 there were list of possible errors with RPN numbers, severity, occurrence and how to eliminate significant failures in packages. Possible risks points can be avoided by analysis at the design early design phase. The DFMEA helps also to determine package related requirements and options. Possible changes which are made and sometimes needed can be documented in this tool and this provides information that can be utilized in the future both in design and testing.

4.9 Fiskars Test Lab and Quality

In Fiskars test lab, the products are tested during the product development phase. The tests in the lab performed based to test standards or based on internal standard method. Some cases there are no test standards available, for example for example axe hitting test then the test specialist can also create their own test methods according the specific purpose. Also, some cases Fiskars can choose to test these products using available test methods anyway, but the testing is not based on requirements set on the product or supplier.

In this case most of the test are done by using tensile tester in internal test lab. The tensile tester can test strength, the yield strength and the breaking strength from packages. Testing provides information on the strength, toughness and stiffness properties of the material, and the behavior of the material during the draw is seen.

Test finding are reported to package or product designer during development phase example wrong marking on the packaging when compared to artwork file or package specification. Case project Fiskars internal test are described in next chapter.

4.10 Consumer package test validation for HOQ II result

According the QFD HOQ II Pareto results (Fig. 23) main test requirements for consumer package which need to be verified during NPD are:

- Design check
  - Design check validation is done as a defined internal packaging guideline to check product try me feature, product does not cover package text, and package color and dimensions are according the specification. This has been checked by the packaging engineer.
- Transportation testing
  - Testing is done according to the internal transportation guideline. In this case transportation tests are done based on the risk evaluation during the QFD process and the team has decided to check transportation durability as a ‘’real life test’’ during the product development phase. Packaged product has been shipped through from supplier with small parcel services such as UPS or FedEx and transportation performance has been checked at the end of supply chain. Table 5 which is part of product test report shows the fail result in T2 version. Package team has done improvements to the T3 version and issues which have been seen in T2 are corrected in T3 version.

- Package try me durability (product tear of test)
  - Internal tear off test is done by hanging packages with Euro hole(appendix 1). It is tested by the test engineer. The test method and result are presented below Fig. 29.

The test result gives as a confirmation to the packaging designer whether the result is at an acceptable level. Based on the result this has been a pass by the internal requirement for minimum tearing force.

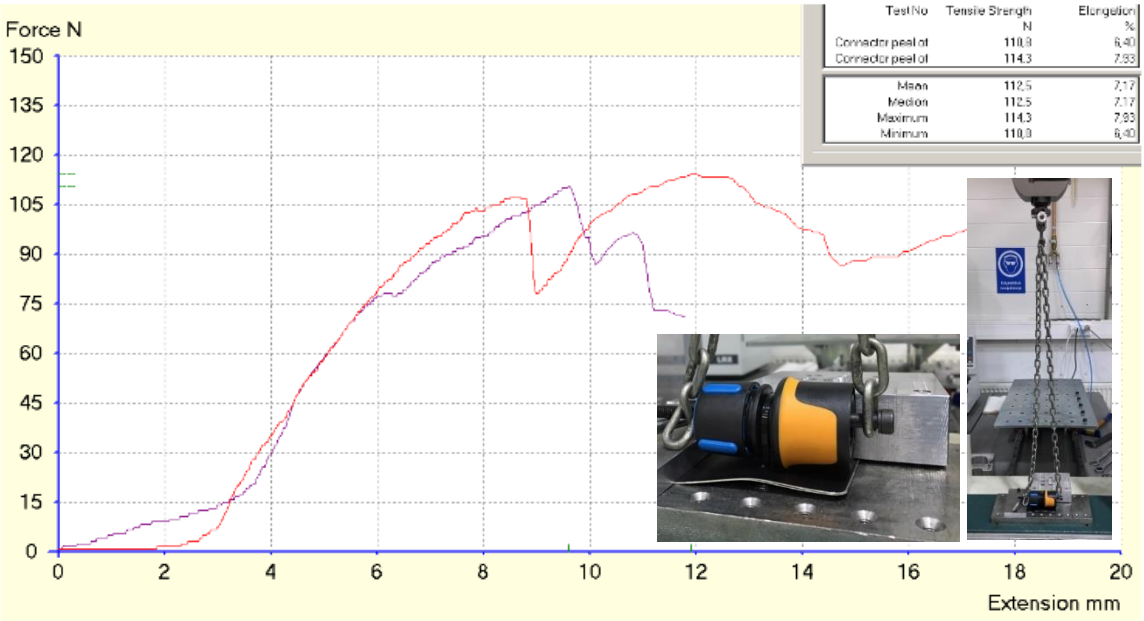


Figure 29. Product tear off test result

- Material thickness
  - Material thickness should be according to the 2D drawing. Material has been selected as FBB 350 from the below Table 3. Material is defined by the packaging engineer.

Table 3. Fiskars paperboard material requirements

CARDBOARD SPECIFICATION

Cartonboard	Grammage ISO 536	Thickness ISO 534	Bending stiffness ISO 5628 MD/CD	Smoothness ISO 8791-4	Tearing resistance TAPPI 496	Gloss 75° ISO 8254-1	Brightness ISO 2470-1	Whiteness ASTM E313-98
Grade								
SBB,SBS,GZ	250	300	14/7	Max 1,4	-	48	Min 89	Min 95
	300			Max 1,4	-	48	Min 89	Min 95
	350			Max 1,4	-	48	Min 89	Min 95
SUB, GN	270	500	-	Max 2,8	Min 7000	30	Min 78	Min 70
	310		-	Max 2,8	Min 7000	30	Min 78	Min 70
	370		-	Max 2,8	Min 7000	30	Min 78	Min 70
WLC, CCNB, GD	250	280	-	Max 1,5	-	Max 50	Min 80	Min 70
FBB, GC	250	400	37/15	Max 1,3	-	Min 40	Min 80	Min 95
	330			Max 1,3	-	Min 40	Min 80	Min 95
	350			Max 1,3	-	Min 40	Min 80	Min 95

The internal carton board specification specifies required grammage, smoothness, gloss, brightness and whiteness values which are shown in the table above. These requirements are checked comparing with the specification sheet or tested at a 3rd party lab. Results are confidential material and not allowed to share in this research.

- Hook tearing resistance
  - Internal tear off test for hanging packages with Euro hole (appendix 2). Product specific test to verify possible package tearing resistance in hook. Tested by the test engineer. Test method and result is presented below Fig. 30. Test result gives as a confirmation to the packaging designer whether the result is at an acceptable level. Based on the result this has been passed in internal requirement for hanging packages.

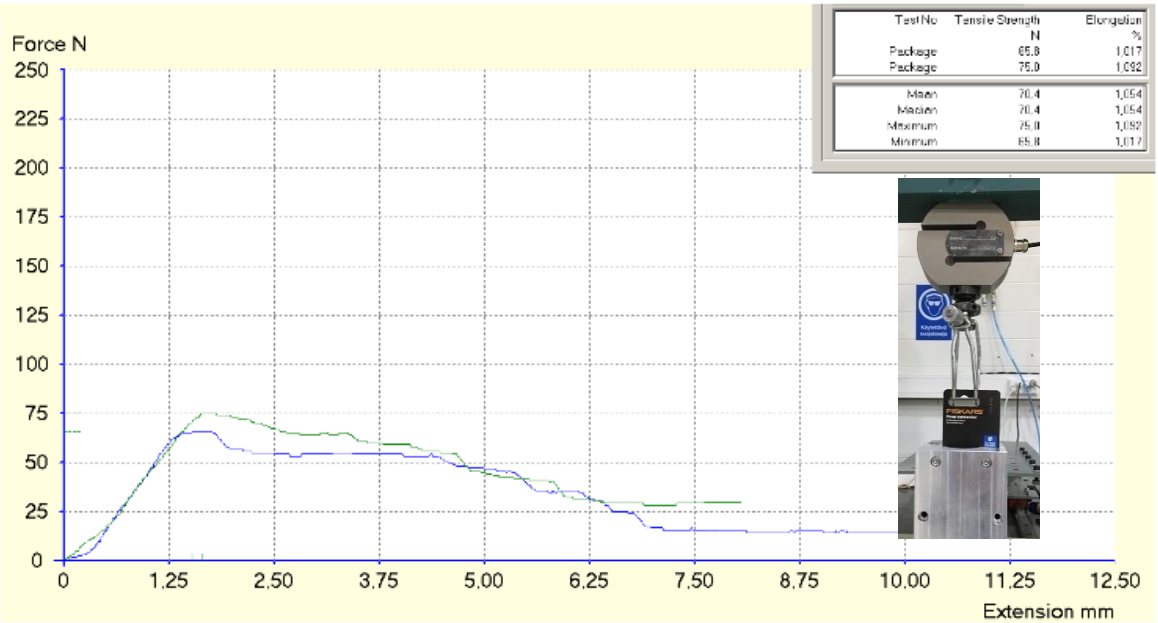


Figure 30. Hook tearing resistance test result

- Printing guideline
  - Package printing must match the specification. Fiskars specific printed corrugated cardboard requirements are shown Table 4 and in this case Fiskars F35P board has been selected. Cardboard printing requirements are specified by the packaging engineer.

Table 4. Corrugated cardboard specification for printing

Corrugated board for printing	Grammage ISO 536 g/m² ± 5 %	Thickness ISO 534 Mm ± 3 %	Bending stiffness ISO 5628 MD/CD Nm ± 10 %	ECT ISO 3037 kN/m ± 10 %	BST ISO 2759 kPa ± 10 %	FCT ISO 3035 kPa ± 10 %	Brightness ISO 2470-1 ± 3 %
Grade							
FISKARS N15P	300	0,6	0,6	1,5	600	530	89
FISKARS G20P	320	0,8	0,6	2,0	600	530	89
FISKARS F35P	350	1,1	0,8	3,5	600	530	89
FISKARS E45P	400	1,7	0,9	4,5	780	420	89
FISKARS B50P	430	3	3,1	5,0	880	360	80
FISKARS B60P	530	4	8,2	6,0	1200	320	80

Cardboard bleached with elemental chlorine is not allowed to use!
Top liner of the corrugated board GC2 or GD2+PP-lamination

Abbreviation

- ECT = Edge Crush Test
- BST= Burst Strength Test
- FCT= Flat Crush Test

Two more validation points are added to the package test report from internal packaging guideline and DFMEA. These are:

- Consumer packages that are to be displayed hanging (speared), must have punched and durable spear holes (Euro-holes). Consumer package Euro- holes must be checked with standard fixture during NPD by the test engineer. If the fitting is correct the result is pass.

- Bar code requirements have been checked according to the ISO / IEC 15416 during NPD phase. The consumer package bar code is identified with bar code reader which gives the specific information about the product, see Fig. 31. If the information from product identification number can be scanned electronically the result is pass.

Figure 31. Barcode on a consumer package(example).

4.11 Package test summary

Conclusions of the package test are presented in Table 5. Package test table is part of the total product test report. Different tests are verified during NPD and the test's PASS / FAIL result is recorded for the different sample versions which are marked in table from version T1 forward. When all tests are passed package is ready for mass production.

Table 5. Package test summary table

Package test	Version / test status					Comments
	T1	T2	T3	T4	T5	
Design check		PASS				
Transportation testing		*FAIL*	PASS			**T2 packages fail in transportation test**
Package try me durability		PASS				
Material thickness		PASS				
Hook tearing resistance			PASS			
Printing guideline		PASS				
Hanging hole feature			PASS			**Fit with Euro-hole fixture**
Bar code			PASS			**According ISO / IEC 15416**

5 DISCUSSION AND ANALYSIS

This chapter will include the conclusions and recommendations derived from the results.

5.1 Quality tools in packaging development

Product development is one of the company's most important processes. By developing customer-oriented products, the company can achieve a competitive edge by satisfying the needs of its customers better than competitors. Customer needs should be considered at the earliest possible stage of product development process to allocate resources from the beginning to the right targets and to minimize the cost of change. According the Trott (2008 p. 406) the customer can be seen in different roles in product development; as a source of data, as part of development work and as a user of a product or service. Therefore, the customer is involved in the product development process at various stages (idea, product design, product testing, product support), depending on the role the company wants to make use of.

The product and package development process must be performed parallel to achieve optimized benefit with during NPD. Adoptions of cross-functional new product developments teams enhances the performance of new product. The findings of Olson, Walker, Ruekert & Bonnerd (2001 pp. 258–271) reveal that new product development is fundamentally a multidisciplinary process and firms are admitting coordinating mechanism and organizational structures increasing level of the functional interaction and interaction during NPD process. For example, cross functional teams and QFD procedures are used in NPD projects aiming at developing highly innovative products or services.

QFD is a structured method of changing customers requirement into technical features and even improve products. In the method, a matrix is created to generate a holistic view of the needs of customers and their mutual importance, as well as determine dependencies on product features. The matrix determines which product features best meet the customer needs and what are the main effects or conflicts between product features. If necessary, QFD matrix is continued similarly to the process properties and manufacturing/work instructions in HOQ 3 and HOQ 4 phases. This research study limited only HOQ I and HOQ II matrix.

5.2 Summary of the discussion part

This study's main conclusion was that the Six Sigma approach works well in this package development project. Tools can be utilized and taken in use during the product development process. Even in this case project where the package was a simple package card, the team has learned much about how to use different tools and what can be done during each development phase. Also, the starting point has been seen that it is better to start with simple case than a very complex approach to get best input from the team results.

When the best possible output is wanted this process needs effort from the whole team to understand the main factors and get the main output for the development process. One of the key outcomes of using QFD is its ability to support teamwork and communication between different stakeholders involved in development and understanding common requirements for each project.

6 CONCLUSION

The purpose of this research was to study systematic methods in packaging development and their use in customer-oriented product development. The subject was interesting and, as the work progressed, it was also interesting to test the theories in practice during the selected case project. Literature review part suggested implementation from the main tools which can be used in packaging design/process improvements and problem solving.

The first research question was how the package quality should be verified during a NPD project. By using a structured QFD approach during the NPD process package development can be improved during the development process. Customer needs are identified systematically during the process and translated into the technical or functional characteristics of the package.

The second research question was how to define the right quality requirements. The Kano and QFD method is one way to simplify the importance of customer requirements to main package quality features. Main customer needs and package quality can be prioritized by using these tools and considering them in package development during NPD.

The third research question was which tools to be used when monitoring or checking packaging quality. Customer requirements are translated to package functionalities/features in the Kano evaluation tool and QFD (House of Quality I) matrix.

HOQ II tool has been implemented package features which are measurable values and these can be validated in internal test lab during NPD project. Design risks analysis DFMEA tool is focusing on package main risk and effects. Possible issues in the customer and required actions are identified and considered before product / package is launched to the market. Product validation tests are evaluating how product design meets the customer requirements / expectations and can be reported with measurable values in a specific test report.

The fourth research question was how packaging quality is to be documented and reported in Fiskars. Main tools are presented in research results. These tools are QFD and product specific test reports from package related tests. The package test is implemented as part of

product test report. This case study considers only package related activities during NPD process.

Systematic package development is an important part as a competitive advantage in many industries nowadays. By using the QFD method the product development process can be greatly improved if the principles of the method are well understood in the organization. The method is very competitive compared to conventional product development, although its implementation requires a lot of effort and commitment on the part of the organization. The experience in taking the QFD process in use has been very positive in this case. QFD has helped with the traceability of key customer requirements and these can be verified systematically through the product development process.

Product development is one of the company's most important processes and it has also been described in this study that packaging development it is necessary to be integrated part of the product development process. By developing customer-oriented products, the company can achieve a competitive edge by satisfying the needs of its customers competing more effectively. Customer needs and risks should be considered as early as possible to avoid issues in end of the product developing process.

The QFD process may seem at least initially a bit of a heavier and slower process. It is a good idea to practice QFD first with a simpler case and moving to the most demanding processes. By using this process one big benefit is that stakeholders sit down and map critical requirements in early state of the product development process. Also, it can be said that VoC, QFD and DFMEA are not just single tools but can be as a part of the whole NPD process. These activities translate the customer's voice into critical package requirements.

When investing in the early stages of product development process and identifying the needs of customers well in advance, time and money are saved in later phases of development and it can significantly reducing the overall project time. It is worth investing in the early phase, where the most important decision for the whole product development process usually has been done.

6.1 Further research

A suggestion for further research would be to conduct a case study from eCommerce packaging. The increasing online sales requires specific needs from package. How eCommerce aspects are implemented in packages during NPD process and what other requirements are needed to consider during package development that products reach customers in the best possible condition?

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FISKARS PRODUCT REQUIREMENT		PR0339	FISKARS®
Type	Functional	Packaging	
Description	Package try me durability (product tear of test)		

Version	Description	Date	Author
0.7	Document exported from ePDM to Sharepoint	01.11.2018	monnela

Introduction
This test specifies a test method for the strength of package when product has been tried in package. The test is done according to internal test standards.
The aim of this test is to observe the changes in package appearance and possible tearing caused by consumer trying it with package.

Verification and requirements

Test method is presented in picture 1. Product pulled from package by using tensile tester

Package card is attached to tensile tester jig.
Tensile tester speed (50mm/min)

Picture 1. Tensile test apparatus

Samples
At least three unused items are required for the test. All samples must meet the requirement in order the test to be considered as pass.

Evaluation Criteria

Record the highest force

Limit value

To be decided based on product range requirement

Reference directives, requirements and standards

Used standard; Fiskars Standard Product Requirements – SPR (Internal standard)

FISKARS PRODUCT REQUIREMENT		PR0340	FISKARS®
Type	Functional	Packaging	
Description	Package hook tearing resistance		

Version	Description	Date	Author
0.9	Document exported from ePDM to Sharepoint	01.11.2018	monnela

Introduction
This test specifies a test method for the strength of package when product has been tried in package. The test is done according to internal test standards.
The aim of this test is to observe the changes in package appearance and possible tearing from hook caused by consumer trying it with package.

Verification and requirements

Test method is presented in picture 1. Product is peeled from package by using tensile tester

Package card is attached to tensile tester jig
Tensile tester speed (50mm/min)

Euro hole hook to be used

Picture 1. Tensile test apparatus

Samples
At least three unused items are required for the test. All samples must meet the requirement in order the test to be considered as pass.

Evaluation Criteria

Record the highest force

Limit value

To be decided based on product range requirement

Reference directives, requirements and standards

Used standard; Fiskars Standard Product Requirements – SPR (Internal standard)