Risk Management and Loss Optimization at Design Process of Products

Dr. Katalin Németh-Erdődi

Abstract: We'd like to introduce a flexible system of design process elements to support the formation and tool selection of an efficient, „lean" product design process. To do this we identify numerical risk factors and introduce a calculating method for optimising taking into consideration

- *the effect of design steps on usage characteristics,*
- *the time needed by the design elements and the resultant losses,*
- *the effect of design on the success of the implementation process.*

A generic model was developed for harmonising and sequencing of market and technical activities with built-in acceptance phase. The steps of the model can be selected flexibly depending on design goals. The model regards the concurrent character of market, technical and organising activities, the critical speed of information flow between them and the control, decision and confirmation points.

Keywords: Risk analysis, planning of planning, project management, product design, optimisation

1 Introduction

The objective of this paper is to introduce an innovation of traditional product designing process. We think that a company's success is based – not at last – on the systematic, conscious product designing method which meets the market requirements and takes risks as well as resources into consideration.

Product innovation is not only technical subject but also a series of well coordinated activities in which market, professional and strategic aspects should come across. At the end of the innovation process every company wants to achieve an optimum concerning time, costs and the customers' reaction.

2 Aspects of Creating the Methodology of Design Work

It is pivotal question in both cases how quick the company can react to the customers' reactions and to what extent the value of novelty can be realized.

It is a fundamental truth in marketing that the market pays for the novelty and not the perfection of a new product. For this reason it should be considered whether it is really important to develop a "perfect" product which would require a lot of time and money or to create a not completely ideal product but to be the first entering the market by which the company can reap an extra profit.

The surplus of this new approach is that the product designing process will be optimized not only on basis of the quality level but on planning of extreme values based on the expectable maximum profit calculated from the costs of quality/lack of quality, the extra income of being first on the market if possible as well as on the costs of innovation process.

The obtainable final outcome of the company has been analyzed for three strategies and methodologies:

"A" – Fully Planned Product Designing

The goal at developing of the product to be innovated here is maximum fulfilment of the required parameters. Therefore such methods are used in the designing process which ensure the safe accomplishment and thoroughness. This leads to better quality, to the reduction of costs of inside and outside errors, but because of later appearing on the market, only lower price can be realized.

"B" – In Time Reduced Good Designing

This strategy is based on giving up the finding of the optimum for some elements of designing. The goal is only to effectuate the minimum functionality, but the designing period should be as short as possible, without significant reduction of the resources being at disposal. Some designing methods will be eliminated, some others will be used in reduced way.

"C" – Over Reduced Designing

The market requites rapidity with higher turnover but the designing process is done too superficially. This may lead first to higher income but can cause later the withdraw of the market's confidence from the product, the profit will be going down and can turn finally to loss.

The market requites "the first" or those who belong to "the firsts" with higher prices and with larger quantities of sold products. Figure 1 shows the function of number of sold pieces vs time.

Because of fastness of entering the market profits vary in time: they are high at the beginning but at the end they are the same as profits of products not innovated (taken over from others) (Fig. 2).

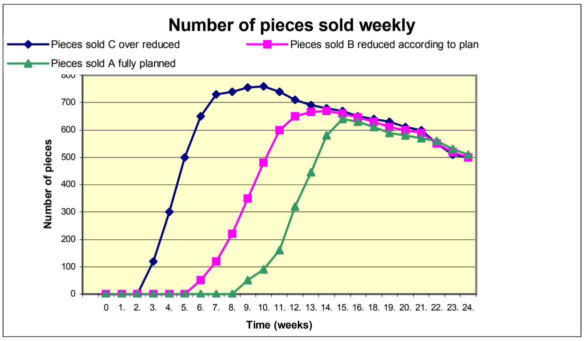

Figure 1

Example for number of sold pieces vs time for various designing strategies. (Data can be collected with suitable marketing appraisal.)

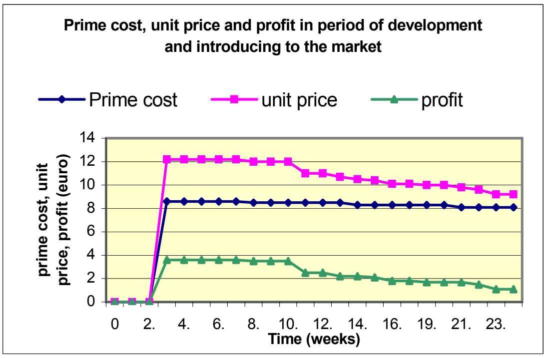

Figure 2

Expectable profit

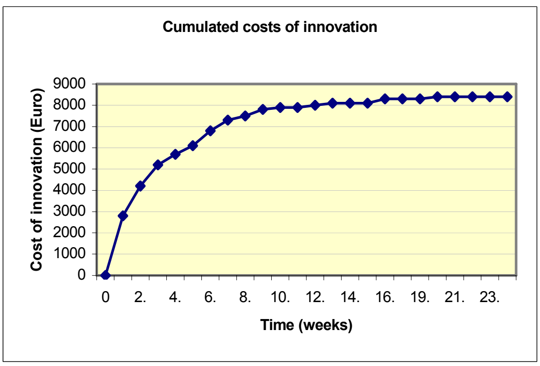

Figure 3

Accumulated costs of innovation in the period of observation

In case of over reduced (accelerated) designing the unit innovation capacity has to be utilized better, effectiveness of designing assures higher profit on the market. With modifications of inside sequence and structure of elements of the innovation process an acceptable but not perfect product can be created. However, innovation can go on later, when the product is already on the market and further resources can be mobilized to improve it.

Costs of errors can be estimated as Fig. 4 shows. Because of early entering the market specific costs of errors are relatively high. These costs of errors referring to the numbers of pieces can be seen on the diagram since they are probably in close connection with the level of innovation.

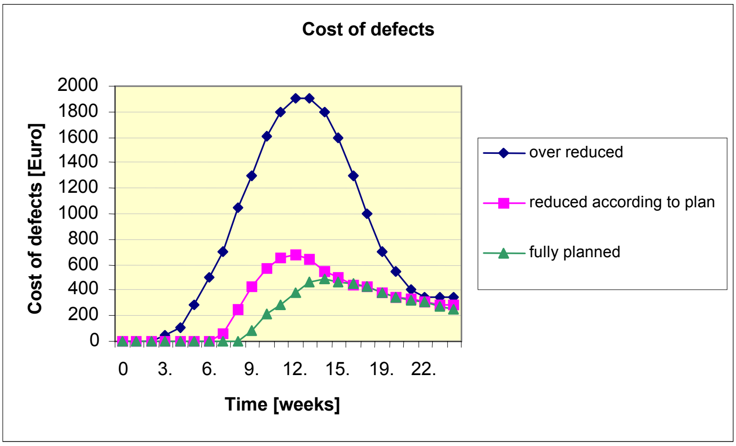

Figure 4
Costs of errors for various designing methods vs time

The final profit or loss can be calculated from the cumulated income (which is given by multiplication of the total number of pieces sold on the market and the profit per piece) minus sum of the cumulated costs of the innovation and those of the errors.

Figure 5 proves that the choice of designing strategy can have essential effect on the economic state of the company. If the development comes late, the result at the beginning is only loss, which, however, later can be reduced by strong but expensive marketing actions. With conscious concentration on the inner sequence of elements of innovation and using effective tools an acceptable however not perfect product can be developed by which extra profit can be booked.

The surplus of the new approach is that requirements for functions of the product have to be confined not only from the bottom but from above too, since they require usually extra costs. Requirements formulated for the designing process have to include the minimum and maximum values of product parameters and the resources connecting with them.

$$\int M(t) * P(t)dt - \int F(t)dt - I(t) \quad (1)$$

where: M(t)- number of pieces sold

P(t)- profit/pieces

F(t) – cost of defects

I(t) – cumulated costs of innovation

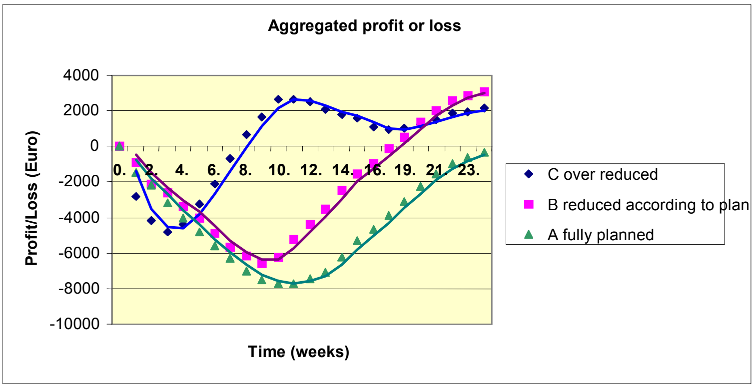

Figure 5

Aggregated profit or loss given by products developed according to the various designing strategies

3 Ideal Designing Process

Successful and effective product design project requires precise coordination of marketing, planning, technical, technological and controlling tasks.

From the complete process which contains each possible step the ones can be chosen consciously that meet the company's aims on the market and its economic interests, and which are optimal for product development process, as well as the resources which can pertain to the process, in order to reach the required result.

In a systematic, well controlled "ideal" designing process there are all those steps which contain the determination of the customers' requirements, the controlling and approving functions as well as the necessary test methods and forms of documentation (Chart 1).

Step No.	Tool	Parameter-No.	Time	Cost
1.	**QFD**			
	Interview			
	Questionnaire			
2.	**Calculation of compromise** (Harrington method)			
3.				
4.	Project planning software			
	Time and resource plan			
5.	Aesthetical design			
	Technical calculations			
	Design of the construction			
	FMEA			
6.	**Design of experim**			
	Trials			
	Lifetime planning			
7.				
8.	Analysis of product parameter			
	Filtering ability to electrosmo			
	Breaking strength			
	.Change of dimensions			
	Trend to pilling			
	Stain repellence			
	Wearing comfort			
	Colour fastness			
9.				
10.	Flow chart			
	Ability tests			
11.	FMEA			
12.				
13.				

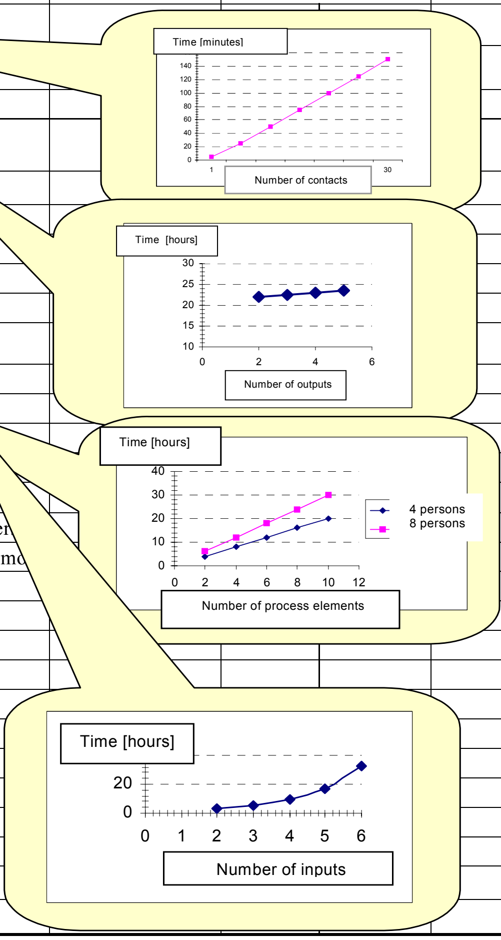

Chart 1
Steps and tools of design

1 - mar ket research, 2 - formulation of the conception, 3 - approval of the conception, 4 - Making a plan for the designing work, 5 - preliminary plan, 6 - elaboration of technology, 7 - model/muster production, 8 - test, experiments, 9 - Verification of the sample, 10 - Process planning, 11 - Production trial, 12 - Approval of the product and the manufacturing process, 13 - Production

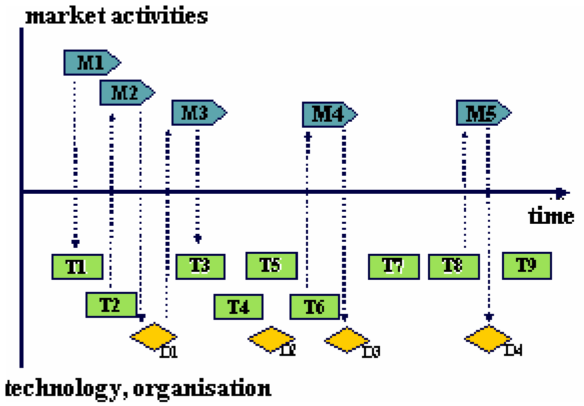

Figure 6
Steps of the ideal designing process

The elements of the complete activity plan for the product design, Fig. 6.

M1 - Market surveys; **T1** - Survey of internal innovative potential; **T2** - Formation of product ideas; **M2** - Market risk analysis of product ideas; **D1**- Acceptance of product idea, decision; **M3** - Survey of concrete consumer demands QFD, interview, questionnaire, product presentation…); **T3** - Determination of design, formation of compromises; **T4 -** Risk analysis, product design, Risk analysis of production process**; D2** - Decision on design model, based on risk analysis

T5 - Process of product design; **T6** - (muster/model) production; **M4** - Prototype demonstration to the consumer; **D3** - Acceptance of muster, decision on prototype acceptance; **T7** - Process design; **T8** - Trial production; **M5** - Customer judgement; **D4** - Acceptance of product and process; **T9** - Evaluation of remarks, Feedback.

4 Possible Risks of the Design Process. Method of Risk Calculation

Every project of innovation means risk. Before starting an innovation project worth to assess the market risk and the risk of product realisation and to decide on the way and cost of product development taking into consideration the acceptable risk.

The risk of product realisation appears as a question at the key elements of design:

- At formulating the design concept,
- At developing the product,
- At developing the process.

The risk assessment is done by the following expression in case of arbitrary Ai event:

$$Ki = P(Ai) \times G(Ai) \qquad (2)$$

where: K – risk rate of Ai elementary event, measurement units as of G

P – probability of Ai event

G – financial or other resource with sign (loss of gain) connecting to the realisation of Ai event

i – ordinal of every element (aspect) of the (I) product development (innovative) process, not neglectable respecting the model.

The risk calculation can be made by assessing the real value of the probabilities, losses and the resource need, or just to inform on preliminary comparing, when we don't need numerically each factor, only the comparative importance of these.

In this case we can use artificially made risk numbers to evaluate the risks. We assess the "i" probability and the possible loss or gain connecting to the individual events comparing to each other on a scale. The risk numbers composing a product compared to each other are capable for doing decisions on the design process.

5 Process and Methodology of Design a Special Technical Textile (Protective Garment against Electrosmog)

The goal is to develop a knitted shirt which protects the human organism from influx of electromagnetic waves of range of 1000 to 30 000 Hz. This should be a knitted fabric in which metal fibres create a so-called Faraday-cage. Because of wearing comfort these metal fibres must be embedded in a cotton yarn.

Technical requirements to be achieved are as follows:

- good shielding effect,
- fabric parameters (area density, elongation, change of dimensions, air permeability, moisture absorption) which makes the product suitable for making T-shirt. Target values have been established for all of these parameters.

Strategically it is important to come to the market as soon as possible which means that the development work should be completed in one month. The product must be not very expensive, middle-class people who want to take care of health must be able to pay for it.

5.1 Planning of the Development Work, Choice of Convenient Methods

There are steps in the development work that require more or less constant time, like making project plan, approval, etc. In addition, there are other creative activities that are necessary to reach the final product – their time spans and costs have been estimated.

Setting up of parameterized toolbar needs the most extensive knowledge of technology and the technology is at disposal for every pre-designing process and using it, processes with required number of parameters can be designed quickly and precisely.

Chart 1 contains the steps of designing process and the possible individual tools. From this toolbar the proper methods can be chosen, with respect to time optimization.

Planning of time and costs is supported by pre-determined time and cost functions. Setting the time and cost, limits can be decided whether the goal is a quickly or a fully elaborated product and what methods should be used in the development work.

We can introduce the scheme of creating a toolbar by using the so-called 2^p design of experiment.

Now it can be arranged in an expert's surface to which tools of problem identification and analysis can be fitted to create one system. Using this, it is relatively simple to chose a solution for the problem in question, for the specific possible tools and experts being at disposal, with subjective evaluation (e.g. on a scale from 6 to 10) or within the frame of correct data identification. Elements of the functions can be determined individually, their connection with the parameters can be estimated or calculated precisely, thus the function gives discrete result to the specific task.

5.1.1 Method of Design of Experiment

Optimization of parameters offering maximal protecting effect can be made using design of experiment.

It is often required that the product be the cheapest, the strongest, give the highest performance, etc. Optimizations is determination of extreme values. If the effects, exerting influence on a certain parameter, and the contact of these effects with the parameter to be optimized are known, the values can be calculated that give the optimum. In the practice, one single parameter is influenced by more than one effect (factor) from which usually only the most important ones can be watched closely. The name "2p" refers to the fact that the number of parameters to be examined is p and the number of levels on which each parameter is examined is 2.

Thus, the total number of variations, in which input factors can be examined without repetitions is 2p. This is the total number of the experiments to be tried.

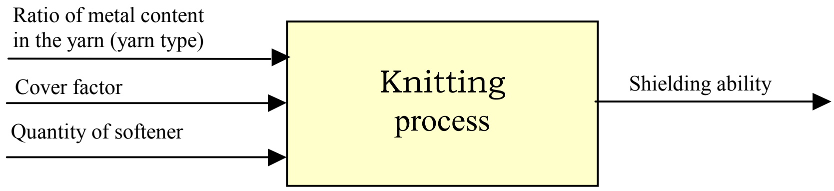

Figure 7
Modell of design of experiments

5.1.2 Cost Function of Design of Experiment (Example)

Cost function is this:

$$K= 2^p K_a+2^p(t_1+t_2+t_3+t_4)k_m \quad (3)$$

where Ka– cost of materials

t_1 – preparation time, making of design of experiment

t_2 – time required for a specific experiment (making sample)

t_3 – time for tests (tests of samples, measurements)

t_4 – time for evaluation (analysing of test results)

k_m – gross salary

With cost and time functions we can advocate making a plan for the designing work.

Conclusions

With conscious concentration on the inner sequence of elements of innovation and using effective tools an acceptable however not perfect product can be developed by which extra profit can be booked. From the complete process which contains each possible step the ones can be chosen consciously that meet the company's aims on the market and its economic interests, and which are optimal for product development process, as well as the resources which can pertain to the process, in order to reach the required result.

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