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THE CUSTOMER'S VOICE IN THE PRODUCT QUALITY ASSURANCE

Rok Tomaževič [1], Janez Kušar [2] and Marko Starbek [3]

[1] CIMOS d.d., Marežganskega upora 2, SI-6000 Koper, Slovenija, E-mail: rok.tomazevic@cimos.si

[2] Faculty of Mechanical Engineering, Aškerčeva 6, SI-1000 Ljubljana, Slovenia, E-mail: janez.kusar@fs.uni-lj.si

[3] Faculty of Mechanical Engineering, Aškerčeva 6, SI-1000 Ljubljana, Slovenia, E-mail: marko.starbek@fs.uni-lj.si

ABSTRACT

The companies of today are facing new challenges: global business and local operation, standardization and individualization of products, demanding customers and fierce competition.
The company wants to achieve better competitiveness with shorter product and processes development time, lower costs and high quality of the products. In order to achieve the set goal, the company has to take into account the customers wants and needs already during new-products-development process.
This article will present the phases of quality functions deployment (QFD) during new-products-development process along with the location for obtaining, structuring and evaluation of customer needs.
Also presented will be the results of testing the proposed methodology of taking into account the voice of the customers in the process of developing a new car component in a company which is development supplier in the automotive industry.

Key words: QFD, internal/external customers, obtaining customer needs, structuring and evaluation of customer needs, decision-making process

1. Introduction

The complexity of the products has increased multi-fold. The final product now consists of a number of assemblies and parts, each fulfilling a distinct function. Systems engineering demands that product realization is treated as a system-centered problem, as opposed to component-centered. System engineering accepts the idea of divisions of labour, but it emphasizes the cooperation between the divisions. The changing market conditions and international competitiveness are making the time-to-market a fast shrinking target.

The marketing managers, design and manufacturing engineers must work together as teams in order to improve quality and reduce costs, weight and lead time. Competition has forced the organizations to devise concepts like time compression (fast-to-market), concurrent engineering, design for X-ability, tools and technology, and to integrate them already in the process of designing and developing a product [1, 2]. With conventional product development it is difficult to address all the aspects of total values management (TVM), such as X-abilities, cost, tool and technology, responsiveness and organization issues. In order to compete on the demanding world market it is not enough to only deploy functional quality into a product.

2. Implementation of concurrent engineering in enterprises

The analysis of implementation of CE into SMEs, especially of multidisciplinary teams and their structure and organization, showed that the concepts proposed for large companies differ from concepts for small companies. Small companies are basically unable to support a large number of teams.

Requirements concerning team composition, structure and organization in SME's are:

- The number of sub-teams in a multidisciplinary team should be as low as possible;
- Active participants should have as broad and integral knowledge as possible;
- Specialists are to be included in the team on a part-time basis;
- The number of team levels should be as low as possible in order to promote direct cooperation.

A two-level multidisciplinary team structure has been suggested for small and medium enterprises (Figure 1) [3].

The transition from sequential to concurrent product development should be performed in the following two phases:

- Preparation for concurrent product development;
- Implementation of concurrent product development.

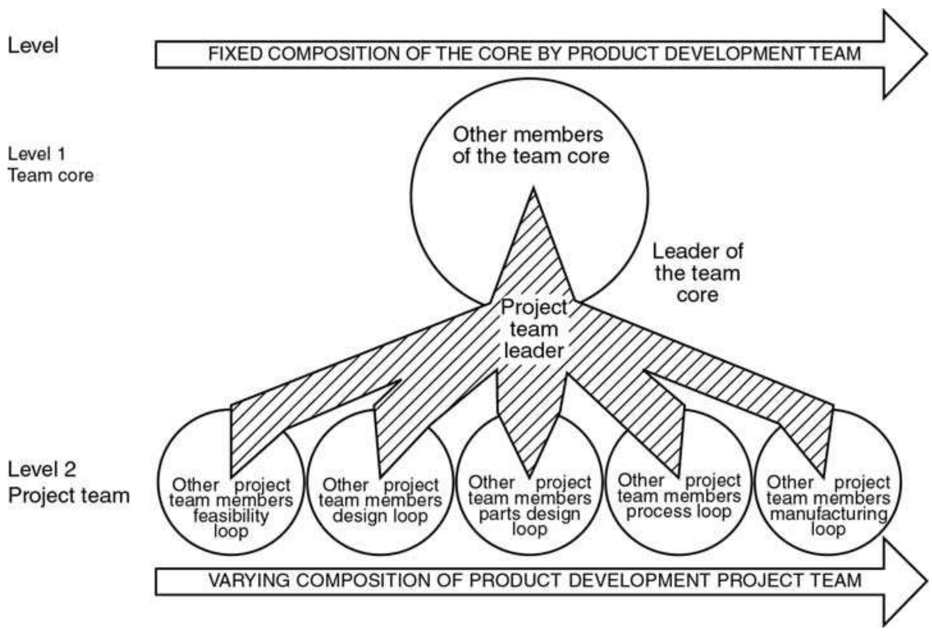

Fig. 1: Two-level structure of teams in small and medium companies.

3. Concurrent engineering tools

A successful implementation of basic concurrent engineering tools and methods is a prerequisite for the subsequent transition to concurrent product development [3, 4].
It is apparent from Figure 2 that QFD and CFD play an important role in the CE product development process.

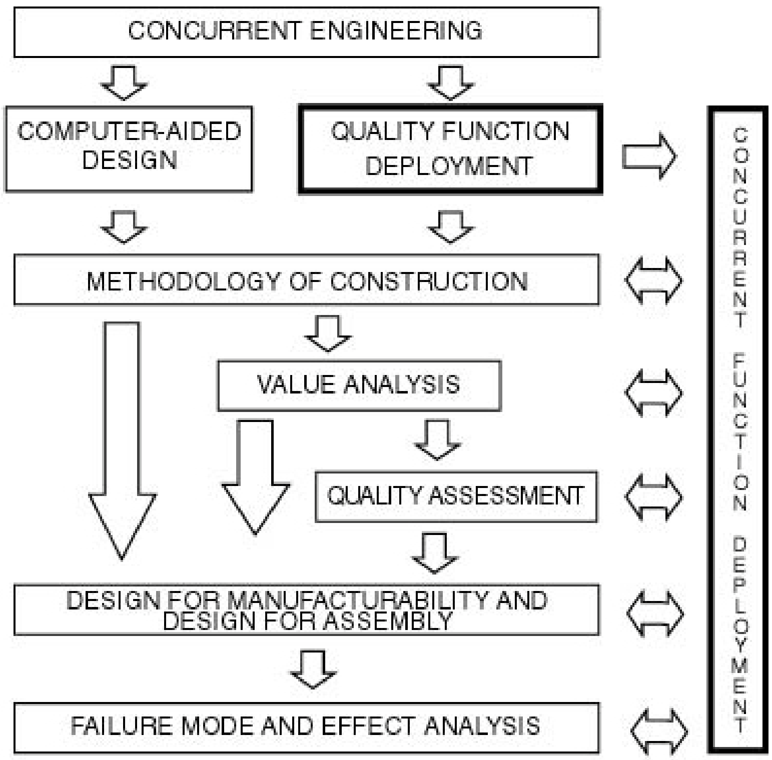

Fig. 2: QFD and CFD as concurrent engineering's tool

4. Concurrent function deployment

4.1. The role of QFD as a concurrent engineering tool

QFD is the central tool supporting concurrent engineering [5]. QFD aims to provide the team with a method of classification of development actions (used to concentrate on actions that will have the greatest impact on customer satisfaction). Without an effective optimization strategy the team would run a risk of optimizing product characteristics that are unimportant to the customer, thereby raising costs.
QFD is explicitly time-consuming (long meetings that have to be attended by a number of people).
The most widely described model for establishing QFD is a four-level model known as the Clausing model or the ASI model [5], see Figure 3. The part characteristics in the QFD ASI model are obtained using a relational hierarchic diagram.

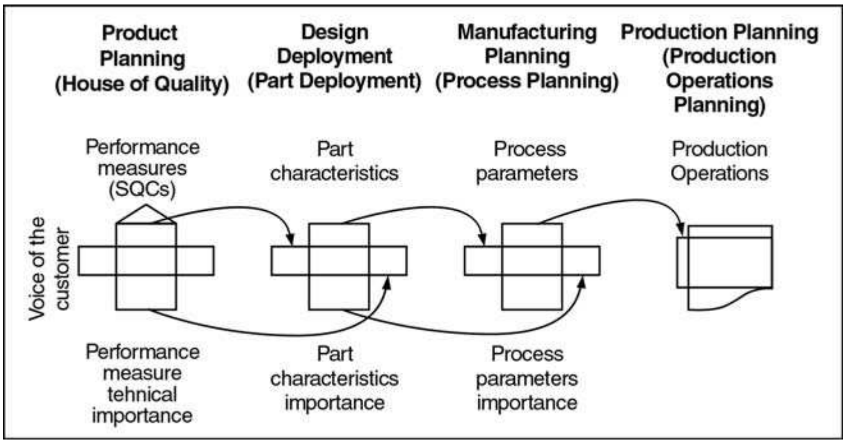

Fig. 3: Four-phase QFD model.

The first step in part characteristics deployment is to develop a function tree (the total product is first divided into subsystems, and the subsystems are divided into parts and their characteristics that have to be evaluated). The serial nature of deployment of this model pushes the QFD into becoming a phase process.

4.2. CFD as an upgrade to QFD

CFD addresses all product values and is less time consuming when compared to QFD.
The basic organizational goals of CFD are [1, 2, 6]: to multiply innovations, organize the infrastructure and improve the company's responsiveness, improve the cooperation inside the company and with external entities, quickly introduce new products to market in a cost-efficient manner. CFD is a concurrent engineering methodology that enforces the notion of concurrency and deploys simultaneously a number of competing product values in addition to quality. With the CFD concept it is possible to simultaneously address different houses of values, such as house of quality, house of X-ability, house of tools and technology, house of costs, house of responsiveness, house of infrastructure etc., thereby enabling better transparency between customer requirements and technical abilities of the company, at the same time reducing the time of product design.
CFD enables the design and manufacturing engineers to start communicating among each other early in the project and to act concurrently during the product, process and production planning phases. In this way the quality of the product is improved and the probability of intermittent errors (which are the most frequent cause of additional costs in development projects) is reduced. The QFD deployment process using the CFD methodology [6] is shown in Figure 4.

4.3. CFD as an upgrade to QFD

In small and medium enterprises CFD is planned in accordance with the proposed methodology of variable CE team structure (Figure 1). The methodology is described in detail in the case study. Sub-teams of variable structure are formed and their task is to generate individual matrices (houses) using the CFD methodology at the level of product, process and production planning. Analysis of different methods of teamwork organization has shown that it is advisable for the entire team to work together at the beginning (so it can acquire or supplement customer demands and their corresponding technical characteristics and pave the way for the CFD process) and afterwards in sub-teams. The project manager/CFD facilitator must individually (in phases) cooperate with all concurrent groups and transfer the data, which is common to all houses of values. From time to time it is necessary to assemble the sub-teams (the whole team) so they can perform reconciliation between CFD houses.

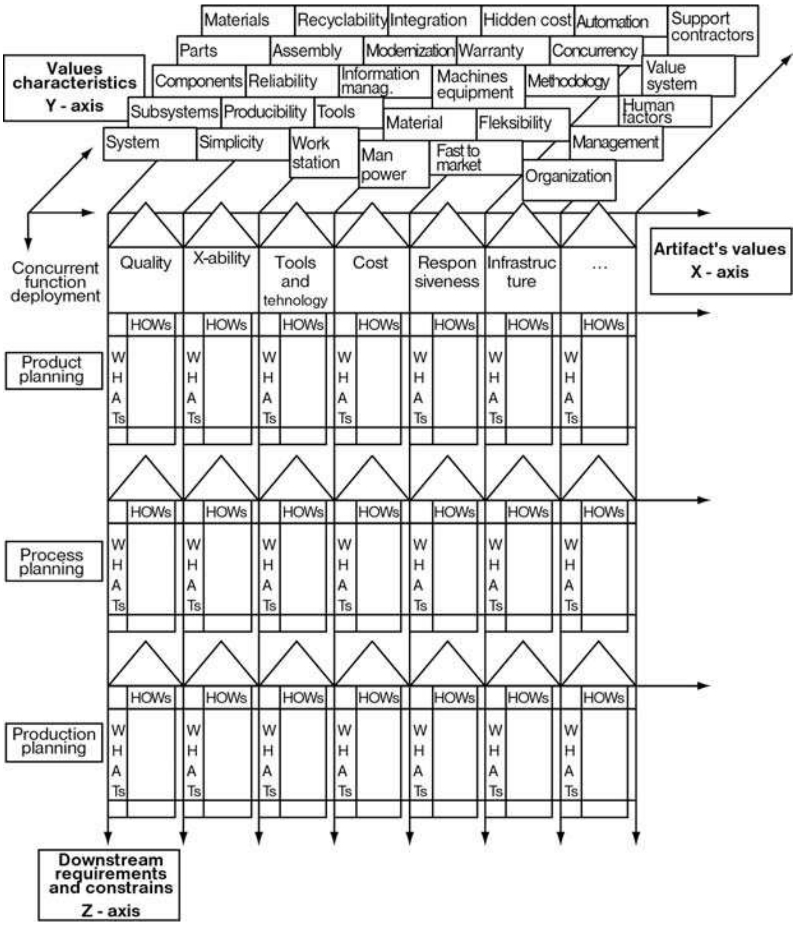

Fig. 4: Concurrent function deployment.

5. Case study

Our goal was to research the processes that are most important for the improvement of product quality on the case study of a brake pedal. To carry out the experiment, a team of experts was assembled from all company departments that participate in the product planning process.
The expert team's task was to determine how to improve the quality, lower the costs and shorten the product planning time.

The analysis was executed in six steps.

Step 1: Obtaining product characteristics as inputs (WHATs) for the house of quality.

We began from customer requirements upon the presentation of initial samples of brake pedal. The requirements were stated on the assembly drawing of the final product and on the drawings of respective components, as well as in the book of requirements for the presentation of initial samples. The requirements were entered into the house of quality as product characteristics. 30 product characteristics were determined.

Step 2: Analysis and determination of importance of obtained product characteristics.

The initial product characteristics were reconciled with the customer already in the development phase, and some additional necessary characteristics arose upon the presentation of initial samples to the customers. We made a decision to treat all characteristics as equally important.

Step 3: Listing the processes of product creation (HOWs) and their entry into the house of quality.

We made an inventory of processes and activities that are taking the place in various company departments and are necessary for a quality product to come into the existence. Both were obtained during a team workshop using classical brainstorming method and direct interviews with the representatives of individual departments.
We discussed processes and activities in all company departments that participate in the product planning: from receiving inspection, forming, welding, welding laboratory, metallurgical laboratory, machining, painting, assembly, measurement laboratory, quality planning to developmental laboratory.
80 processes and activities important for the creation of a product were named.

Step 4: Analysing the house of quality

Relations between product characteristics (WHATs) and obtained processes (HOWs) were entered into the process quality house. The house of quality for the brake pedal made with program Qualica [7].

The house of process quality has shown that all processes taking place in the departments named above contribute towards product quality. Figure 5 shows the percentage share of contributions of processes executed in individual departments towards the product quality.

Continuing the analysis of house of quality for the brake pedal, we made a decision to look in greater detail into the processes of individual departments that contribute the most towards product quality.

Receiving inspection department:

The receiving inspection department issues a cover sheet for bought parts, confirming the product fulfils the requirements of procedures and standards for the presentation of initial samples. In the house of quality of processes, related to the receiving inspection department, it is evident that the contributions towards the quality do not differ much between individual bought parts and semi-manufactured products. Most important for product quality is the process of inspection of documentation and issuing the cover sheet for the pedal lining and the insert for the push bar, while the least contribution towards quality is given by the inspection and issuing the documentation for sheet metal. This can be explained by the fact that the receiving inspector has to put more effort into inspecting a pedal lining than into inspecting the documentation for sheet metal.

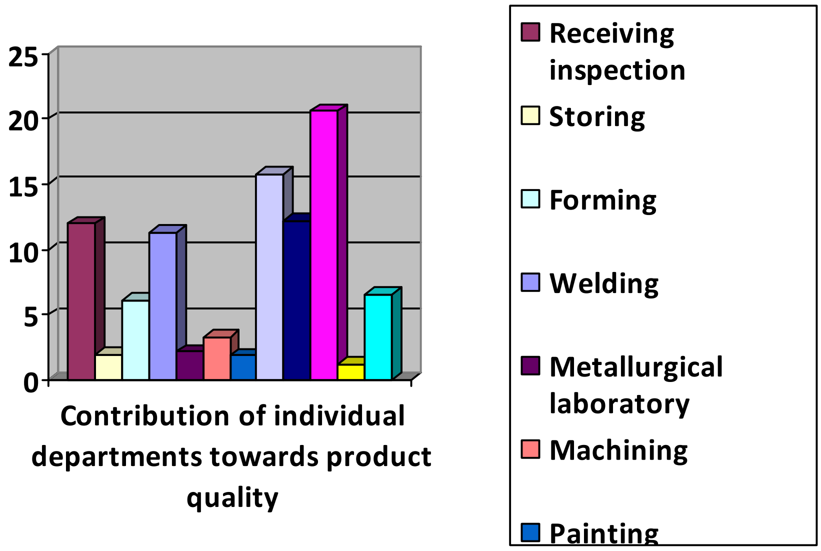

Fig. 5: The contribution of individual company departments towards product quality

Forming department:

A finding for the forming department was that it is important to carry out FMEA for forming of all components. The most important is FMEA for the auxiliary lever, as it has the largest contribution towards the quality of the whole product.

Welding department:

The findings for the welding department are that it is the most important to carry out FMEA for welding, the second most important is the determination of welding parameters and the third most important activity is the selection of the proper welding wire.

Metallurgical laboratory and welding laboratory:

The metallurgical laboratory first cuts the welds and then verifies whether the welds are made in accordance with the prescribed standards. The report on the results of the investigation are submitted to the quality department.

Machining department:

Most important for this department is the FMEA of machining process and the execution of manufacturability study.

Painting department:

The painting department has to ensure surface protection, so they carry out a paint stripping test that must conform to standard as well.

Assembly department:

Most important for the assembly department is the execution of FMEA of assembly and the supply of dimensionally proper components to the assembly line, which is enabled by good manufacturability and proper control during the previous processes.

Measurement laboratory:

The most important activity done by the measurement laboratory is the creation of a measuring programme for the final product and validation whether the CAD models are in accordance with the drawings of individual components.

Quality planning department:

For the quality planning department it is the most important to obtain from every other department the documents necessary for the initial sampling. The following activities are listed by their importance: statistical tracking of reports on dimensional measurements made on components and product, creation of a control plan for the final product and preparing the control procedure for the final product.

Ecology department:

The task of ecology department is to ensure data acknowledging that all components are in accordance with ecological norms.

Developmental laboratory:

The developmental laboratory carries out all physical experiments required by the customer.

Packaging department:

The most important activity is designing the packaging for the final product, followed by designing the packaging for bought parts.

The house of process planning, created in Step 4, was analysed according to the QFD methodology. There were 30 input data items – product characteristics, and 80 processes were taken into the account. This means there were 2400 relations in total. If it takes half a minute for each relation, this means it takes 20 hours to fill the matrix. This is a quite time-consuming process, but it saves us time in the future by showing vividly which processes are necessary to plan a quality product and which processes contribute the most towards the making of a quality product. It also enables the representatives from every department to have a role in the process of product planning, to present their knowledge about the product and exchange their opinions with co-workers.

Step 5: Concurrent deployment of houses of department processes in the X direction.

The problem of time consumption in the creation of a large house of processes deployed using QFD methodology and created under Step 4 could be solved by the methodology of concurrent deployment of CFD product functions by breaking the common house of quality into individual house of processes for the departments. In our case, this would yield 12 houses to treat the processes of individual departments. The houses would be smaller in scope, more transparent and easier to handle. The relations of houses of processes by department could be solved concurrently meaning up to 10-times less time would be used.

Step 6: Concurrent deployment of houses of department processes in the Y direction.

In case we find out the given constructional drawings do not enable a realisation of processes on the level of concurrent houses of processes, we can decide for concurrent deployment of houses of processes by departments for X-abilities in the Y direction (Figure 4).

We will present in the following some examples of houses of processes by departments for X-abilities in the Y direction.

1. House of manufacturability for forming

In case the FMEA of forming proves the design of auxiliary lever is not appropriate for manufacturing, the house of manufacturability for forming will deal with the design to propose better solutions (technical characteristics) for production and forward them to the development department.

2. House of manufacturability for machining

In case the FMEA of machining proves the design is not feasible for manufacturing in the given framework of cost, the house of manufacturability for machining is used to find better design solutions (technical characteristics) for production (wider tolerances, design that facilitates clamping) which are then forwarded to the development department.

3. House of control in assembly

In case the design involves fastening elements that must not drop out of the assembly under a certain load, these elements should be controlled under a certain load. The design concept must enable control on the assembly line. This can be ensured by using the design-for-assembly concept.

6. Conclusions

The article presents the experimental building of a house of process quality for the manufacturing of a brake pedal. The goal of building the house of quality is to discover the possible ways for early discovery of faults in the product, process and production planning. The results of experiment point to the following important findings:

- Every department involved in the product planning process contribute towards product quality.
- There are processes in any department that contributes to the product quality by a larger amount than the other processes.
- Important processes can be recognised by using the house of quality of processes, so we can focus on the processes that contribute the most towards product quality.
- The time to discover activities that contribute the most towards product quality can be shortened by using the CFD methodology, which makes it possible to break a large house into multiple smaller houses and deal with them concurrently. Such houses are also more transparent and easier to process. In this way, we can use up to 10 times less time.
- In case the product drawing does not enable the product to be manufactured with quality and within the given framework of cost, it is the most important to change the drawing as soon as possible to enable an undisturbed process of manufacturing of a quality product. This is made possible by the CFD method through deployment of houses on the level of processes in the Y direction for the value of X-ability.
- It was found out that if we want for the product planning process to go as smoothly as possible, we must not only take into the account the voice of external customer, but also the voice of internal customer.

Further investigations will be directed into the use of the method of deployment of values, which enable an easier feasibility, manufacturability, assemblability, clamping, quality control already on the level of product development and obtaining of its characteristics.

7. References

[1] Prasad B. 1996. *Concurrent Engineering Fundamentals: Integrated Product and Process Organization. Vol. I*. New Jersey: Prentice Hall.

[2] Prasad, B. 1996. Concurrent Engineering Wheels. *The RASSP Digest* Vol 3, 1st Qtr.

[3] Duhovnik J., Starbek M., Dwivedi S.N. and Prasad B. 2001. Development of New Products in Small Companies. *Concurrent engineering: Research and Applications* Volume 9, Number 3, September 2001.

[4] Kušar J., Starbek M., Grum J. 2001. House of Quality and concurrent engineering. *Proceedings of the 6th international conference of the Slovenian society for non-destructive testing*, Portorose, September 2001: 375-383.

[5] Cohen L. 1995. *Quality function deployment – How to Make QFD Work for You*. Reading: Addison Wesley Longman, Inc.

[6] Prasad B. 1997. *Concurrent Engineering Fundamentals: Integrated Product Development. Vol. II*. New Jersey: Prentice Hall.

[7] Qualica 2003. *QUALICA QFD User Guide*. München: Qualica Software GmbH.