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QFD METHOD - A MODEL FOR PRODUCT IMPROVEMENT AND DEVELOPMENT

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Abstract: Nowadays, in the global market products and services need to have factors that exceed expectations if the manufacturer wants to be one of the leading market players, and they have to fulfill all the basic and customer requirements. Very often there is a large percentage of working time which is wasted in communication in order to clarify misunderstandings, correct mistakes, and sometimes reorganize improper work activities. To avoid these losses, more time has to be spent on analyzing and planning to meet customer requirements. The QFD method is a comprehensive method for quality planning and management in the product creation process. This why it is necessary to perform systematic monitoring and measurement in all processes, primarily on the basis of set goals in terms of time, costs and product quality. The paper presents the use of the QFD method to improve the existing product, a device for automatic pressure adjustment in car tires. According to the QFD methodology, all participants are provided with a system analysis in the realization of products through four phases, from customer requirements to all definitions of the work process. Also, the goal is to achieve a reduction in the number of work instructions. The fourth matrix shows key processes with performance and graded significance. These are processes that require special attention during production design, in order to improve a product and make it meet customer expectations.
Keywords: Quality Function Deployment, Voice of the Customer, product improvement

1. INTRODUCTION

The abbreviation QFD stands for Quality Function Deployment, but QFD most often means quality planning focused on customer/user requirements [1]. Toyota has been using the QFD method since 1973. It was later adopted by Honda (1979), Ford (1983), Volvo and Saab (1987). In the more developed countries of Western Europe and the USA, it reached wider application in 1991.

Nowadays, the QFD method is an integral part of national standardized methods used in Japan. The QFD method is a multi-stage planning process, which takes into consideration complete customer satisfaction, by including all employees in the organization. This contributes to achieving the three most important goals of the organization:

- to deliver the expected products (good quality),
- that the products are delivered on time (on time) and
- to produce offers at a real price (real profit).

From the perspective of the customer / user, the product is associated with satisfaction and price, and from the perspective of the manufacturer, the product is associated with design, development and production process. However, the quality of a product or service is determined by the relationship between the wishes and needs of users and their realization by the manufacturer. Therefore, the main goal of applying the QFD method is to serve the purpose of designing or improving the product/ service exactly according to the requirements of customers/users.

Quality Function Deployment, or simply QFD (Akao, 1990; Clausing, 1994; Cohen, 1995), has been an important tool in the translation of the voice of the customer (VoC) into product's specification. It has been widely used for product development and quality improvement around the World. It is a customer-oriented approach, supporting design teams in developing new products based on an assessment of customer needs. Basically, in the QFD, customer needs are translated into design attributes. The design attributes are then deployed in process and quality requirements [1].

"Once upon a time, people could order a pair of shoes directly from a craftsman / shoemaker. By measuring the customer's foot and personally dealing with all aspects of the workmanship, the shoemaker could make sure the customer was satisfied," commented Dr. Yoji Akao, one of the founders of the QFD method, in his private lectures [2].

2. QFD METHODOLOGY

The QFD method can be applied successfully, in the case of the development of a completely new product or in the case of the improvement of an existing product. Firstly, it is necessary to identify and define the

requirements of end users, known as the "voice of the customer". The analysis of customer requirements is performed on the basis of data from: sales, marketing and development, servicing department, carefully designed surveys/questionnaires and later during other phases of the QFD map, based on data obtained using quality tools (FTA, FMEA, and FMECA; cause-effect diagrams; tree diagrams; Taguchi procedure; SPC techniques, etc.)

The QFD method requires teamwork and engagement of employees from all areas of the production process [3]. The QFD method is a planning guideline for the systematic development of quality with the requirement of how to increase customer and employee satisfaction, and thus to ensure the business success of the organization. The application of the QFD method is based on *the opinion of customers* (market language - the voice of the customer) which is translated into the desired product (*technical language - the voice of the engineer*, Figure 1). The goal of the QFD method is to translate *customer requirements* into *product quality characteristics*. Quality characteristics are all the characteristics of a product / service that contribute to meeting the required quality of the product/ service.

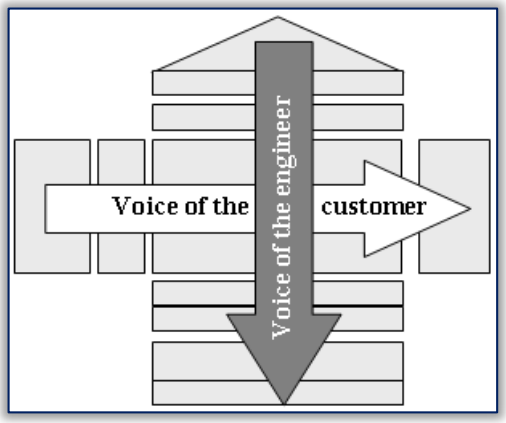

Figure 1. Transforming market language into technical language

A large percentage of working time is spent in communication to clarify misunderstandings, correct mistakes, and often reorganize poorly planned arrangements. To avoid these losses, more than ten percent of working time needs to be used for analysis and planning. The QFD method is a comprehensive method for quality planning and management in the product creation process, where it is necessary to perform systematic monitoring and measurement in all processes, with regard to the goals in terms of time, cost and product quality [1].

In the QFD matrix, the goal of each endeavor is characterized by *What*? (e.g., *What does the customer want*?). The implementation of strategies and measures is described with *How*? (e.g., *How are customer requirements enforced*?). The process of implementing a QFD map is a consistent question-and-answer game of two basic questions: *What*? and *How*? The answers to these questions are entered in the House of Quality [4].The QFD method uses the term "quality house" because the matrix used to document the QFD process resembles a house drawing.

The application of the QFD method today has virtually no restrictions on use. When it comes to production, the QFD method can be applied equally successfully, in the case of the development of a completely new product (at different stages of development of this product) or in the case of improvement of an existing product.

— A new approach to the QFD method

QFD continues to have very significant applications worldwide, resulting in new approaches in applying this method in new areas of business. The modern approach to the QFD method was developed by experts from the QFD institute, and the most significant progress in recent years has been given by the new ISO 16355 standard.

The classic approach refers to the four-phase QFD model or the use of only the "house of quality matrix" adopted by the US auto industry, all with the aim of responding as quickly as possible to the expansion of the Japanese car industry in the 1980s.

A modern approach, was developed by researchers of the QFD method in the US in response to the demands of the software industry and adaptation to a turbulent environment. Their focus was not "how" to solve the problem, but „which problems are solved first". The modern application of the QFD method has shifted the focus to business analysts, customers, competitors and strategic planning and thus created new tools to connect their work with design and development.

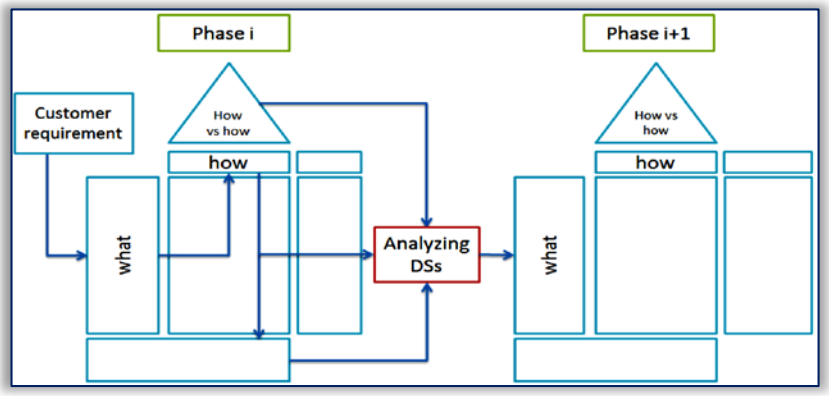

Figure 2. A new way of transition between QFD matrices [5]

Many researchers have used approaches based on morphological analysis and graph theory to develop new systems for the transition between QFD phases [5, 7]. This approach seeks to use the transition, retaining the "customer voice" as the main function to be fulfilled (Fig. 2).

The usual transition between phases involves transferring all design specifications from the columns of the existing matrix to the rows of the next one. While on the other hand, simplified, the mentioned new approach includes a "roof of quality house" (which describes the interrelationships of the design specifications) to obtain the significance of the specifications. After calculation, by methods of linear programming and optimization, only those combinations of specifications that have positive and neutral mutual relations are selected. The final combination is the one that achieves the greatest functionality, taking into account all the values of the relations.

The implementation of the QFD method consists of a series of planned steps grouped into four phases, which are connected to each other, and which are preceded by the basic phase, i.e. determining customer requirements. A quality house is built for each phase, with each quality house having its own entrance and exit. It is important that the goals that go into one quality house, such as e.g. customer requirements, turn into quality characteristics and again emerge as clearly formulated goals for the next process phase - the next quality house [6,7].

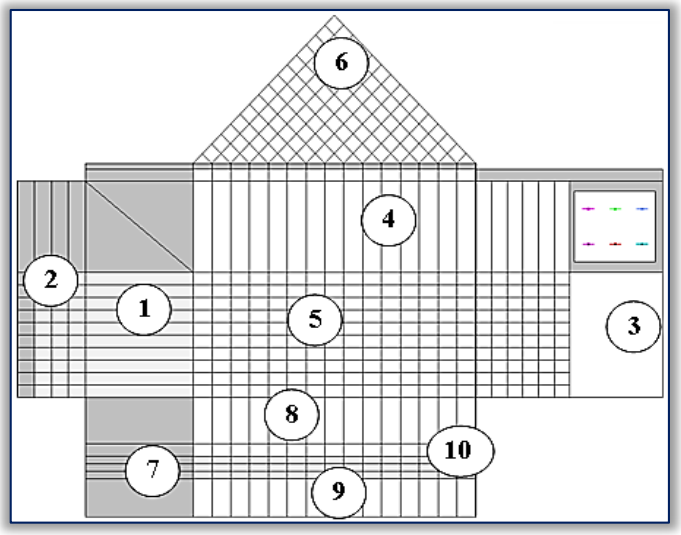

Figure 3. The House of Quality (HOQ)

— **The House of Quality (HOQ) – structure**

Each quality house is realized through ten steps, and Figure 4 gives an overview and order of all ten steps [7, 8].

- Step 1 – Customer/user requirements: What users want - The QFD method begins by collecting customer requirements related to the product description and their characteristics defined by the customer.
- Step 2 – Degree and relative significance: Ranking the characteristics of the products defined by the customer, according to their importance. The ranking scale is based on perception and personal feelings, with a numerical evaluation of product characteristics (usually a scale from 1 to 5).
- Step 3 – Comparison with the competition: Based on the benchmarking analysis, the characteristics of the observed product are compared with the characteristics of competing products (Scale 1 – 5).
- Step 4 – Engineering characteristics: Engineering characteristics expressed in measurable parameters so that they can be grouped according to their functional requirements, while monitoring the direction of progress of their target values. The functional decomposition components of the product are used to distribute the engineering characteristics in the quality house.
- Step 5 – Relationship Matrix: A relationship matrix is a means of identifying the degree of impact between each engineering characteristic and user requirements. Using scales 9, 3, 1 gives different severity of the influence of engineering characteristics on a certain functional requirement.
- Step 6 – Correlation: The correlation matrix shows the degree of interaction between the engineering characteristics of the product.
- Step 7 – Degree of technical significance: Absolute significance, which is the sum of the numerical values of all elements of the product in the column of the relation matrix with their corresponding ranking performed by the customer. Relative significance, which represents the percentage determination of the total numerical result that each engineering characteristic has.
- Step 8 – Target values (quality characteristics): Target values for each engineering characteristic of the product, obtained in part from benchmarking or from an independent assessment of how strongly the values affect product performance (quality characteristics, target values and direction of change).
- Step 9 – Technical comparison with competitors: A technical competitive assessment, which compares the competitive specifications of each product's engineering characteristics and the target values to be achieved or exceeded.
- Step 10 – Degree of complexity of quality characteristics: The degree of technical complexity represents the values that indicate the ease with which each product characteristic can be achieved.

In the case of improving an existing product, the need for improvement can be expressed for several reasons: new customer requirements, desire to improve product characteristics, problems that arise in the exploitation

of products, monitoring the development of such products in competition, etc. The main goal is to identify critical points on the already existing product and in the process of its production, which are important for meeting customer requirements or for improving product characteristics in order to, depending on the goal, identify activities for improvement.

3. APPLICATION OF THE QFD FOR PRODUCT IMPROVEMENT

The selected example relates to the improvement of an existing product, a device for automatically adjusting the pressure in car tires [11] (Fig. 4).

Based on market research, customer surveys, processing of information from the database of the sales and service department, data on customer requirements were obtained, as shown in the Table 1.

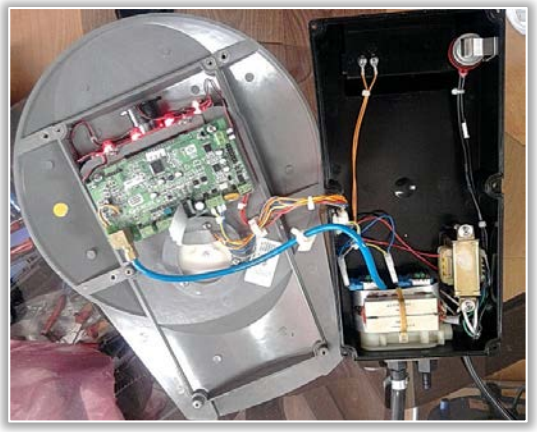

Figure 4. The appearance of the disassembled device for automatic pressure adjustment in car tires [11]

Tabela 1. Voice of the customer (VoC)

QUALITY CATEGORY	CUSTOMER / USER REQUIREMENTS
Performance	Accurate tire pressure measurement Satisfactory precision Satisfactory measurement range Quick automatic tire pressure adjustment
Additional requirements	Easy installation Small device dimensions Easily readable results Possible reading in the dark Audible signal to complete the pressure adjustment process Light signal to complete the pressure adjustment process Lower device price in comparison to the competition
Reliability	No maintenance required during the life cycle of the device
Adaptability	There is no danger of electric shock There is no danger of sparks
Endurance	Impact resistant Insensitivity to high frequency work cycles Corrosion resistance Moisture resistance Resistance to low temperatures
Service	It requires no maintenance during the life cycle of the device Possibility of calibration in the field Own diagnostics
Aesthetics	Simple product shape lines Attractive design
Expected quality	Low product price

After defining the customer requirements, the requirements that are crucial among them are determined by one of the mentioned methods, and the process of forming QFD matrices through four phases begins. In the first house of quality, quality characteristics are defined based on key user requirements (Fig. 5). The paper also presents another quality house, where the key parts of the product are defined (Fig. 6).

4. CONCLUSION

Based on a detailed QFD analysis, all key measures and activities should be obtained that have to be taken to realize a product that meets the needs and requirements of customers EXACTLY to the extent necessary. All activities will be given a quantitatively expressed significance in the realization of the required quality of the product, service, or process.

At the output, after a comprehensive analysis of process parameters from the point of view of the possibility of failure / error and the probability of their detection (using FMEA), determine:

- measures to be taken in the process itself,
- quality assurance plans and
- operating instructions.

Through the implementation of all phases according to the QFD methodology, defined work instructions are obtained, whereby all participants are provided with an overview of all product characteristics from customer requirements to product realization. Also, one of the important goals is to reduce the number of operating instructions.

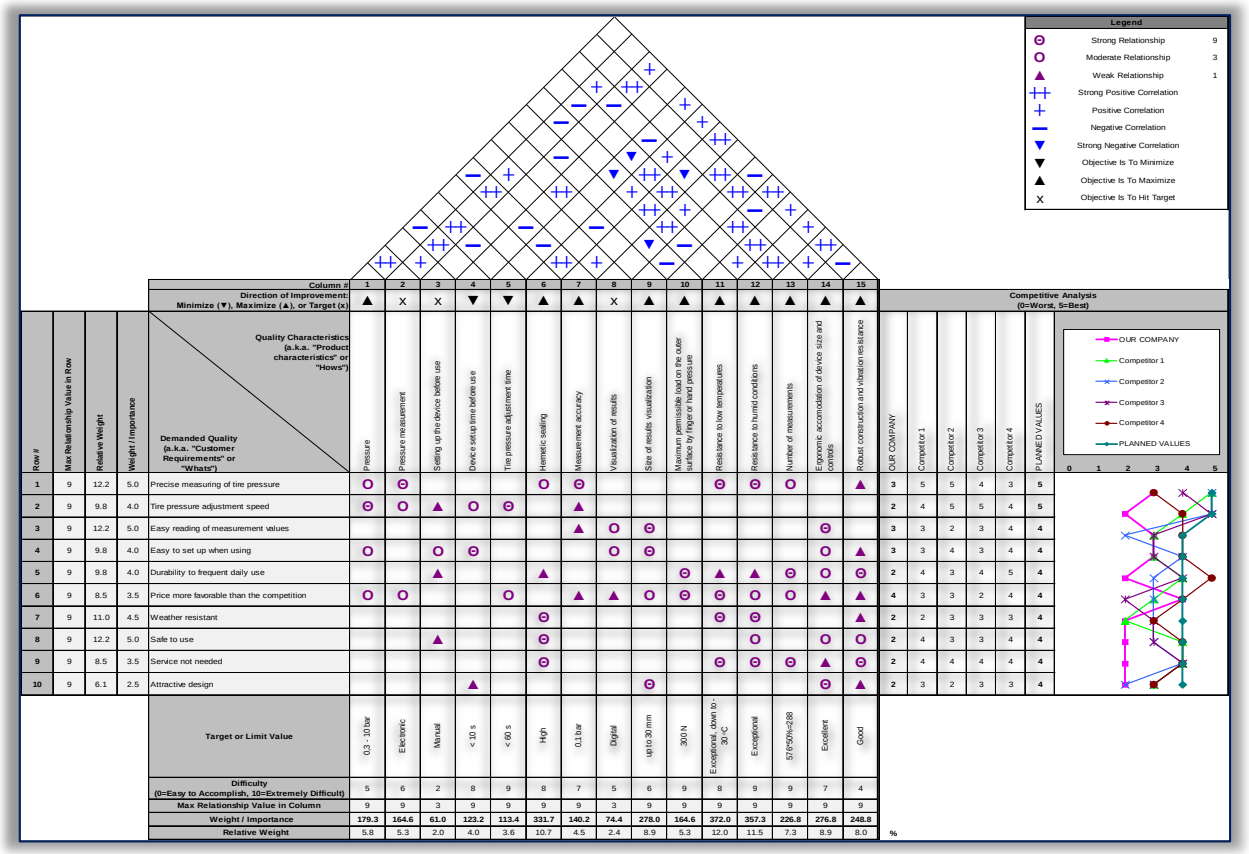

Figure 5. QFD phase I - product characteristics

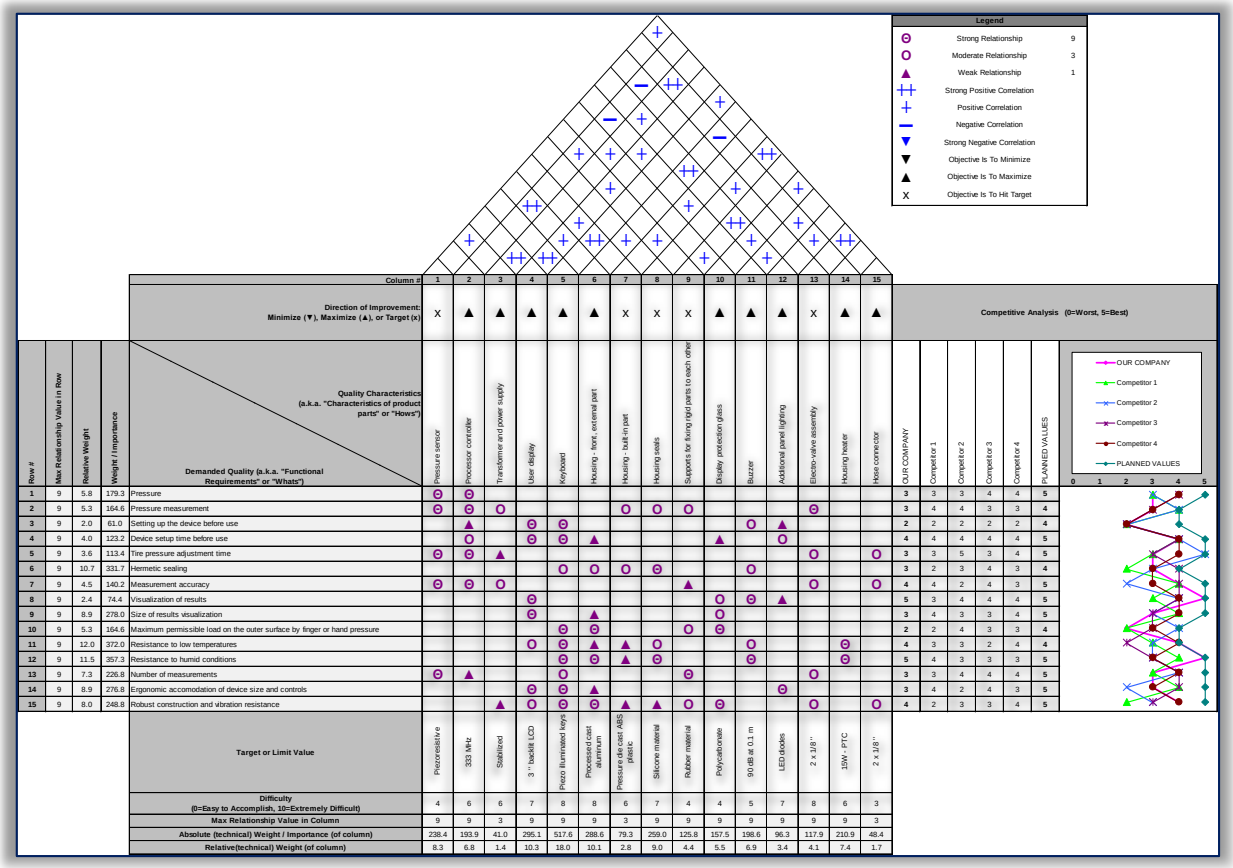

Figure 6. QFD phase II - product parts

With the aim of improving the product based on defined user requirements through the application of the QFD method, key processes have been determined that need special attention during the product design and production process, so that the improved product meets the expected market requirements:

- treatment of sealing surfaces (very fine manual processing - 245.7),
- installation of seals (manual - 231.2),
- threading on the outer part of the housing (increased precision - 249.3)
- checking hermeticity (vacuum pump - 232.9) and
- cleanliness when making hermetic joints (ensure cleanliness of components and working space - 215.5).

Note:

This paper is based on the paper presented at International Conference on Applied Sciences – ICAS 2021, organized by University Politehnica Timisoara – Faculty of Engineering Hunedoara (ROMANIA) and University of Banja Luka, Faculty of Mechanical Engineering Banja Luka (BOSNIA & HERZEGOVINA), in Hunedoara, ROMANIA, 12–14 May, 2021.

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ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665