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## **QUALITY MANAGEMENT IN THE CONTOURS OF CONTINUOUS PRODUCT IMPROVEMENT**

**Abstract:** *This paper analyzes the effectiveness of Quality Function Deployment (QFD) to ensure the success of product development and improvement projects through a better understanding of customer needs, as well as procedures and processes to enhance communication by integrating the Voice of the Customer (VoC), obtained through quality methods and tools, to the House of Quality (HoQ), to support information processing and strategic decision making in the product development or improvement process. For the technical procedures the QFD tool was adopted. Excel software was also used to create the QFD spreadsheet and to visualize how the project design would look another software contributed, CATIA V5. From the results it can be concluded that a training program must accompany the creation of a new project. Everyone involved, customers, suppliers, employees, and management need to be aligned and use the same communication channel.*

**Keywords:** *Quality; QFD; Support; Truck; Transportation*

### **1. Introduction**

The consumer has several options for selecting similar products. Most consumers choose based on their overall perception of quality or value. Consumers generally want the best possible return on their money. To stay competitive, companies need to identify what is important to increase the consumer's perception of the value or quality of a product or service (Machado et al., 2020). The elaboration of a plans is fundamental for the organization of the plans, define which product characteristics, such as reliability, style, or performance, shape the customer's

perception of quality and value. Organizations gather and integrate Voice of Customer (VoC) in the design and manufacturing of their products (Barbosa et al., 2020; Chen et al., 2020; Iqbal & Grigg, 2020; Pongwat, 2019; Felix et al., 2029a). These companies are using a structured process to define the wants and needs of their customers and turn them into specific product designs and process plans to produce products that satisfy the customer's needs. The process or tool they are using is called Quality Function Deployment (QFD) (Lapinskienė & Motuzienė, 2021; Rianmora & Werawatganon, 2021; Wu & Liao, 2021).

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The QFD is a construction of a set of matrices, of which the most widely used is the House of Quality (HoQ). These are the tables that ensure customer satisfaction and better quality services for all levels of product development. In the QFD matrix are in the rows, the customer needs (customer requirements) and in the columns, the response developed by the work team to satisfy these needs pointed out (Iqbal & Grigg, 2020; Rebecca & Putra, 2019). It also contains other sub-matrices, the so-called "rooms", which allow us to assess the positioning in relation to the competition, highlighting the aspects that need to be improved in order to obtain a product or service with high added value. The correlation of information occurs between the competition and after obtaining the VoC. The end of this construction of the HoQ will be when the development team is able to establish the technical specifications of the product (Augusto & Carnevali, 2008; Santos et al., 2019b; Rebecca & Putra, 2019; Siva, 2012; Santos et al., 2019a; Felix et al., 2029b).

Some segments, such as the truck segment, surprised initial expectations due to their strong expansion. We highlight the sales of heavy and extra-heavy trucks, which are the most sought after in the market, and they carry quality, robustness, and efficiency. The agricultural sector contributed a lot to the performance of the truck industry, both to meet the demand in the field and for the high production of grains, requiring logistics from the field to the arrival in ports to export this production (Grandi et al., 2020; Rianmora & Werawatganon, 2021; Xiao et al., 2020a; Xiao et al., 2020b; Castro et al., 2020). In this context, the guiding question that will lead this work is: How to efficiently use QFD? With the purpose of solving it, this article aims to analyze the implementation of QFD in a practical case.

## **2. Theoretical Referential**

In this section the scientific literature is reviewed to introduce the theoretical foundations of Quality Management topics.

### **2.1 Quality Function Deployment**

During interviews it can be difficult to get a clear expression from clients about the consequences that are important to them. Sometimes customers are not even aware of the important consequences (Ishak et al., 2020; Rianmora & Werawatganon, 2021). For this reason, since its introduction, QFD has been used in conjunction with various techniques, such as the Kano Model, SERVQUAL among others. The Kano Model is a theory of product development and customer satisfaction. In their model, they distinguish three types of product requirements that influence customer satisfaction in different ways when met: "mandatory", "one-dimensional" and "attractive" quality requirements (Ishak et al., 2020; Wu & Liao, 2021; Santos et al., 2020). SERVQUAL, in turn, is a service quality tool based on customer perception and expected performance. It is one of the most widely used models for the evolution of service quality. The integration of the Kano Model and SERVQUAL into QFD serves as an effective tool in assessing the quality of an organization's products, leading to increased customer satisfaction and higher profits (Sulphey & Jasim, 2020; Rianmora & Werawatganon, 2021; Shengjin & Jichuan, 2021).

QFD is an adaptation of some tools used in Total Quality Management (TQM). It is a method for encouraging product development team members to communicate more effectively with each other using a complex set of data. QFD helps teams to formulate business problems and possible solutions (Barua, 2021; Silva et al., 2021a; Wu & Liu, 2021; Bravi et al., 2021; Zgodavova et al., 2020).

QFD is a powerful planning tool. The starting point, by with assurance process for the items in the Ishikawa Diagram to identify the VoC (effect) and identify the characteristics of the quality replacement project, procedures (causes) needed to control and measure (Iqbal & Grigg, 2020; Kisku et al., 2017; Silva et al., 2020a).

QFD involves building a set of matrix diagrams, called quality tables, that ensure customer satisfaction and better quality services at all levels of the product development process. The first matrix of the QFD method is called the HoQ, because its appearance with its roof-like structure resembles a house. The HoQ consists of several "rooms", each containing information about the product. The main goal is to convert customer demands into technical product requirements that must be met throughout the supply chain (Oddershede et al., 2019; Saragih et al., 2020; Susanto & Andriana, 2020). The HoQ is a type of concept map that provides the means for planning and its cross-functional communications. The correlation of information occurs between competition and after the VoC is obtained. The end of this HoQ construction will be when the development team is able to establish the technical specifications of the product (Augusto & Carnevali, 2008; Rianmora & Werawatganon, 2021; Rebecca & Putra, 2019).

HoQ, one of the most commonly used matrices in QFD methodology, is a decision matrix toolbox and customer requirements and competitive benchmarks are used for decision making (Ishak et al., 2020; Rebecca & Putra, 2019). The construction of the HoQ begins with determining customer demands. Other terms used are VoC or quality characteristics. After analyzing the customer consequences, the next step in building the HoQ is developing the technical requirements. The technical requirements of the product are the design specifications that meet the customer consequences. These technical requirements are at the top of the

HoQ. They describe "how" to meet customer consequences and improve a product or service (Idrees et al., 2019; Oddershede et al., 2019).

## **2.2 Voice of Customer**

VoC is obtained primarily by two methods, through interviews or focus groups, conducted by a cross-functional team, which are used to develop a research questionnaire to distribute to potential, existing or new customers and ask them what is important to them in the product or service in question. Interviews with 20 to 30 customers should identify 90% or more of the customer needs in a relatively homogeneous customer segment (Esterman et al., 2008; Iqbal & Grigg, 2020). The goal of deployment is to allow the unknown to become known, what is implicit to be made explicit, or what is informing to be formalized (Iqbal & Grigg, 2020; Ishak et al., 2020; Rianmora & Werawatganon, 2021; Doiro et al., 2019; Silva et al., 2021b).

Product development, over the years, has moved from the culture of handmade, to industrial, then to manufacturing, responding to the demand for large quantities with a concern to insert quality into these products (Costa et al., 2019; Araújo et al., 2019; Africano et al., 2019; Sá et al., 2020; Santos et al., 2021; Alvarenga et al., 2021). The quality management system is often integrated with other management systems (Santos et al., 2014; Barbosa et al., 2018; Santos et al., 2017; Rebelo et al., 2015; Talapatra et al., 2019; Jiménez-Delgado et al., 2020; Ribeiro et al., 2017), namely the environmental management system (Bravi et al., 2020; Rebelo et al., 2016; Bravi et al., 2019; Silva et al., 2020b; Carvalho et al., 2020). Lean tools can provide valuable help (Azevedo et al., 2019; Cordeiro et al., 2020; Jimenez et al., 2019; Ribeiro et al., 2019; Rodrigues et al., 2019) to reach new businesses (Bravi et al., 2018).

Currently, the need is felt for more individual, customized, personalized

products that respond to the specific demand of small groups (Esterman et al., 2008; Iqbal & Grigg, 2020; Murmura et al., 2021; Bravi et al., 2021; Sá et al., 2019). Capturing the VoC in market research is important for decision making at various stages of the project. Organizations must, through these surveys, obtain as much information about the real needs and desires of the consumer as possible; either through opinion cards distributed at the time of purchase, through an informal conversation, or through a small group of people used as a sample to check the acceptance of the product (Esterman et al., 2008; Pongwat, 2019; Rianmora & Werawatganon, 2021). The product-related elements that determine the purchase value are price, performance characteristics, quality standard, customer specifications, and pre- and post-sales service (Esterman et al., 2008; Saragih et al., 2020).

### **3. Methodological Proposition**

This work can be classified as an applied research, exploratory in nature (Kothari & Garg, 2019). For the technical procedures the QFD tool was adopted. Excel software was also used to create the QFD spreadsheet and to visualize how the project design would look another software contributed, CATIA V5. Bringing a virtual reality and helping the possible interferences during the assembly of the support. The work was developed according to Brazil's standards.

A comparative analysis before the use of this quality tool and after, allowed us to affirm that the implementation was effective when listening to VoC and how planning and organization should be primordial to bring positive results. When it was decided to use the QFD, the project began to be organized to understand the customers' needs and the requirements that would be a priority. The interaction of all participants involved was feasible to determine what would have to be minimized, extinguished, or maximized, giving direction to improvements. With the correlation between the old and the new, it is

possible to relate the strengths, moderates, and weaknesses of the product. Points that were prioritized: customer satisfaction, then the sales argument as well as the increase in quality

### **4. Results and Discussions**

The company in question is responsible for some modifications done on 24-ton trucks. It is considered to be a modification center that provides services for a well-known 24-ton truck automotive industry. In its portfolio there are several modification services, among them the development of the 2nd steering axle, made in a production line, where 6 (six) vehicles are manufactured per day.

The company ZBW in a first moment opted to develop and to produce a resin cardboard cover, that says that the second directional axle of the load vehicles must be covered by a protection to not cause accident risk to third parties during the route realized to its destination by throwing stones or other objects. For this reason, for the vehicle to be transported to the customers, which are the dealers, the automotive industry, and/or the final buyer of the vehicle as an individual or company, the 2nd steering axle must be covered by a protection. The resin cardboard protection is mounted on an "L" support, 3 mm thick and 700 mm long, which was also developed by the company.

For over a decade of existence of the company studied, the system applied as tire cover was the resin cardboard protection. During the registration of the vehicle, the final customer had to pay for the vehicle registration and knowing that it is not allowed for the vehicle to use resin cardboard as protection for the second steering axle, the customer was forced to change the support and the resin cardboard for a new support along with a new fender. This situation was aggravated by the fact that competing companies already implemented systems that allowed the installation of the

fenders, eliminating future additional expenses.

ZBW listened to VoC to identify which features brought dissatisfaction to the customers. The marketing sector contacted by the customers realized that there was a common discomfort, relating the dissatisfaction of customers to the protection system with resined cardboard, because this was paid for and at the end when the vehicle was delivered to the consumer, the resined cardboard was discarded, causing the customer an additional expense and even an environmental liability when discarding the resined cardboard. Of the 8 items that brought dissatisfaction to the customer, the resined cardboard fender was the item that brought the most discomfort. According to the satisfaction survey conducted by the marketing sector, this item represented 23% compared to the other factors that impacted the added value perceived by the customer.

In this sense, the marketing sector suggested to the engineering sector of the product and projects to think of a solution to the problem pointed out. The solution was to develop a support capable of installing several models of fenders existing in the national market. The product engineering sector decided to use the QFD tool, evaluating the product between the new fender support and the resin cardboard support, and then began to organize the customer needs and project requirements, with the participation of all sectors. Then it determined what had to be minimized, maximized, and what goals had to be achieved, giving a direction for improvement. The correlation between VoC and technical requirements was made and the strengths, moderates, and weaknesses between customer needs and project requirements were related.

The company also made a market evaluation comparing the resin cardboard support with other fender supports. It was assigned 0 = worst evaluation and 5 = best evaluation. This evaluation was also correlated to the "Kano Model", with the customer needs,

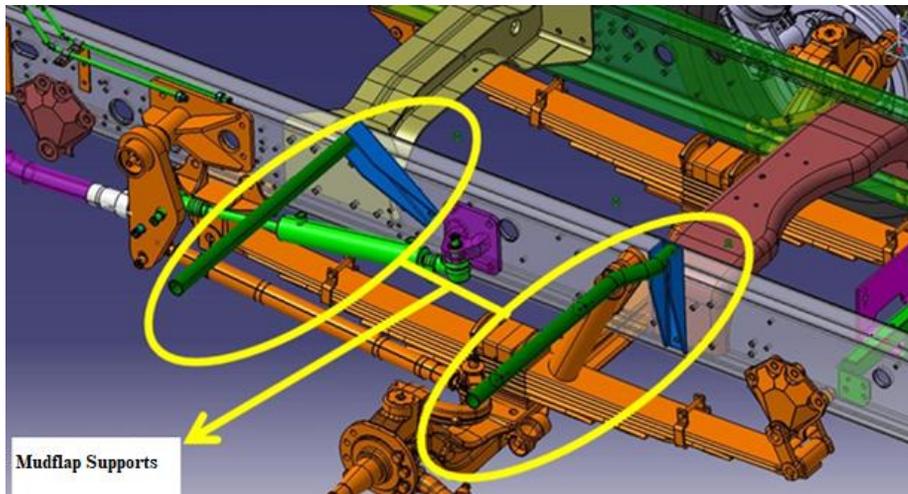
obtaining what the customers considered mandatory (M), expected (E) and attractive (A). The importance and weight of the customer needs were numbered from 1 to 5 in the column "Importance or weight" and the weight of the project requirements were determined to: "Upper Limits", "Target", "Lower Limit" and "Organizational Difficulty". The information was crossed in the relationship matrix, and as a result it was possible to identify the order of performance of the company. After the evaluation it was prioritized the "customer satisfaction", the "sales argument" and the "quality increase", respectively in this order.

Thus, through the construction of the HoQ, which represents the first QFD matrix, the ZBW company obtained an intersection of customer needs with the project requirements, with the old support as a reference and with this, it could distinguish the strengths and weaknesses of the resin cardboard support and the fender support, obtaining a result of acting on the priorities of the project requirements. In the customer's needs, the only parameter that the resinated cardboard and the old support beat the other fenders was in price. Doing a unique and exclusive comparative analysis between (support + resined cardboard) and (new support + mudguard) the company realized that the loss computed for the client with parts and labor, by not changing the installation of the set (support + resined cardboard) for the (new support + mudguard) at the exact moment the truck was on the production line during the assembly of the second directional axle was only R\$ 426,72, discarding the old set (support + resined cardboard) besides the time to make the change.

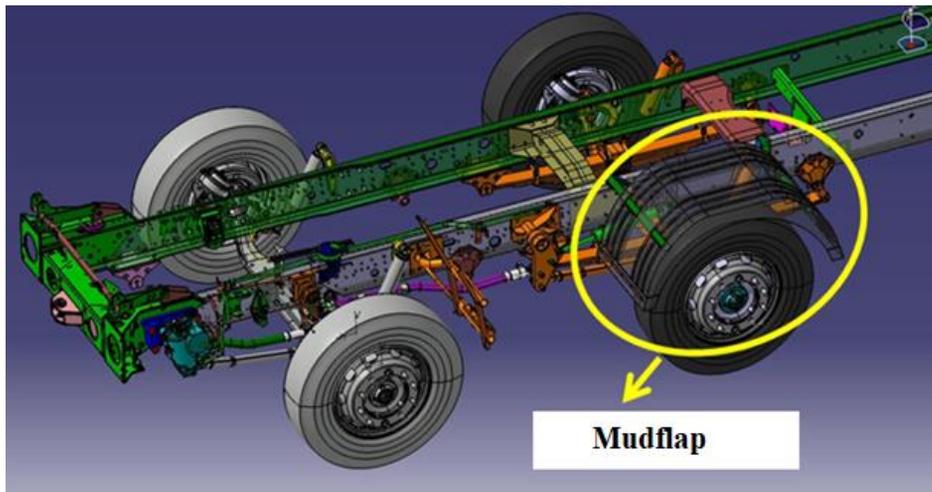
The company decided to use the Catia V5 program to make a virtual model of the (new) fender support and verify possible interferences in its assembly on the production line as well as to obtain the technical characteristics and quantities of the fastening parts. The technical drawings (Figure 1 and Figure 2) for making the

support and the fender were also developed with the supplier, who, in turn, made a

prototype unit (Mockup), for testing on the production line.



**Figure 1.** Second Fender Steering Axle Supports



**Figure 2.** Fender installed on second steer axle support

Figures 1 and 2 are the technical drawings that were made with the team of engineers involved in the project together with the supplier; to verify that the new product would match the data taken from the HoQ. To verify if the project would work in practice, a prototype was built to perform tests on the production line. After this pilot product was approved, the supplier was

qualified to be able to make this implementation, and the series production of the support began. With this modification in the fender the customer already acquires the truck with this support, besides the customer having no additional cost and not needing the service of another company to implement this mandatory item (Figure 3).



**Figure 3.** Tuck 24-ton with fender on the second steered axle implemented

Companies are always looking for new resources in order to reduce costs and improve production processes. ZBW was no different, when it started the development process of this new protection, it can guarantee quality, zero cost and compliance with a mandatory item for circulation of this type of vehicle according to the law.

## 5. Conclusion

The objective of this article was achieved, since the functionality of the QFD quality tool was effective in capturing the customer's needs and voice, planning and executing improvement actions, complying with the legislation, and contributing to the company's competitiveness. It was possible to transform informal characteristics obtained from the customers into the main technical characteristics to be executed. The consumer's feedback is always relevant to the company. Besides the purchase value, quality is fundamental to build loyalty. The organization and correlation of the themes proposed by QFD brings understanding and implementation fast and practical. The more agile the development of any product in the

right way, the more it will be in prominence and projection in the market. The ZBW company is adequate to the market demands and ready to face the competition. Bringing security to customers to use their services and continue in search of studies based on quality tools to be the differential in the market.

Offering a new product to the market requires internal planning of processes and improvements, but we must also highlight the importance of managing internal employees for good communication and process alignment. They are essential to the functioning of the organization, because it is from them that the execution of the work will be well done. A capacity building and training program must accompany the creation of a new project. All those involved, customers, suppliers, employees, and management need to be aligned and using the same communication channel. This type of training raises awareness and recycles for the new. Besides the fact that the market is increasingly complex, the one who updates, innovates, and seeks improvements is better able to make a difference. Dealing with and meeting all the demands requires discipline

and persistence. Organizations in the Industry 4.0 era that wish to prosper and be a reference in their segment need to adapt. It is an essential part of the organization's success. The needs of the automotive industry are increasing. Looking for solutions and ideas to increase operational

efficiency and maximize profit are essential to differentiate from competitors. Today, we are in a worldwide moment of uncertainty; sudden and abrupt changes are part of everyday life and strong threats make organizations need to adapt in the shortest time possible at zero cost.

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