

Quality concepts in Industrial systems using QFD (Quality Function Deployment) – Survey

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Abstract: In this paper, the importance of quality concepts in product development is studied by reviewing several papers from various reputed journals. To improve product design quality, QFD (Quality Function Deployment) is used as a tool that studies the various product design parameters such as aesthetic appeal, cost, service life, Maintenance, etc. In QFD, the analysis is carried out to improve the product design quality based on the customer's evaluation. The use of QFD helps the product development management team make decisions about the product quality by studying and improving its characteristics. There will be a cross functional team in every organization, which comprises design, safety, quality, and Maintenance. With the cross-functional team member's suggestions, it will be possible to improve the product's safety, design, and aesthetic appeal. Hence, in this paper, an attempt has been made to study and review various product design and development characteristics, namely the QFD model, and report several case studies in different industrial applications domains.

Keywords: QFD, Safety, Design, and Maintenance.

I. INTRODUCTION

QFD (Quality Function Deployment) is a tool with customer focus, which helps to strive hard for excellence in product quality by translating the customer needs into specific product design requirements such as the good look of the product in terms of aesthetics, cost, service life and Maintenance. QFD is used to tackle customer-oriented problems related to product services and measuring satisfaction through quality enrichment of product design by improving its technical features such as geometries, dimensions, etc. Chan and Wu [1] defined the QFD as “the set of procedures or system of guidelines used to satisfy the request of customer needs in terms of efficient product design and production process. Generally, QFD comprises 4 phases. The first phase is House of Quality (HOQ), which is said to be the most important segment in deploying the QFD process. In this phase, after finding out the customer needs and Technical Characteristics, the relationships between Customer Needs (CN) and Technical Characteristics (TC) of the product design are determined by finding the weights. In the second phase, Technical characteristics (TC) of product design are converted into customers' specific personal needs.

The product design's critical aspects are considered in the third phase, which the last stage-specific production requirements of the product design. The majority of data of “QFD processes and activities” are used in simple natural language. For example, customer expectations from products are expressed using phrases such as “easy to handle,” “Flexible,” “Safe,” and “Endurance,” which are to be evaluated. The use of FQFD (Fuzzy Quality Function Deployment) with other techniques improves its efficiency and effectiveness. In 1969, Yoji Akao introduced the concept of QFD. He aimed to take advantage of the power of QFD in its product design stage, such that service quality metrics are obtained from product design characteristics. Later many researchers contributed several methods to enhance the power of QFD. The design goal is achieved through quality control, an important activity in the product design stage. The quality control ensures that the design quality conforms to product specifications. QFD is the productive methodology for recognizing the customer perception and connecting them to technical requirements.

QFD manages various heterogeneous team members like the marketing team, Design Engineering Team, and Manufacturing Team to uplift product Quality.

II. LITERATURE REVIEW

This section gives a comprehensive review of Quality Function Deployment literature, which is an important tool to rank technical descriptors of a product based on customers' requirements.

The taxonomy of the literature review of the QFD process is presented in Fig.1.

*.2.1 QFD in product Design Concepts

*.2.2. QFD in Market segment selection and Evaluation



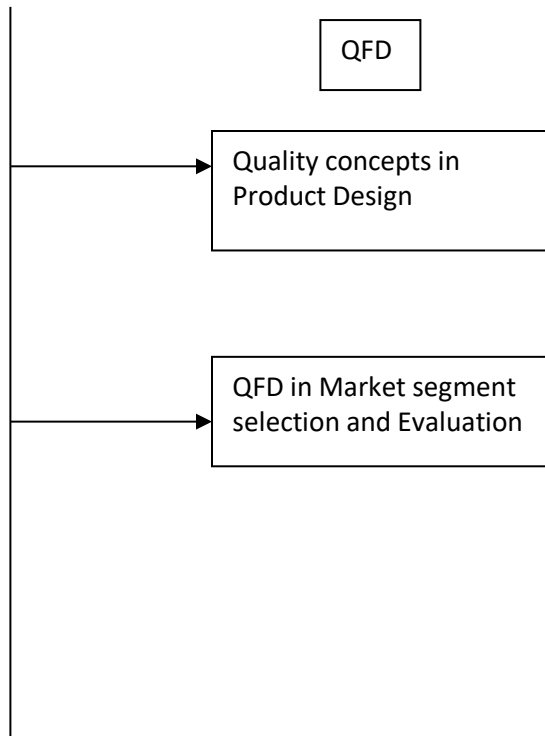


Fig.1 taxonomy of QFD process

***.2.1 QFD in product Design Concepts :**

Abdolshah[1] surveyed two main classifications. The first one tells about a proposed model to develop FQFD (Fuzzy Quality Function Deployment). The second one was focused on new applications of FQFD Models. Most of the research work focused on quantitative methods of QFD, the house of Quality (Phase 1) oriented towards multi-criteria decision-making methods in product development.

Puglieri [2] carried out a survey based on the environmental aspects or eco-design of the product development process with various techniques, tools, and procedural methods, but in other literary works, many authors do not focus on environmental aspects of product quality. This paper has three broad categories 1. Determining eco-design and operational aspects of the product development process. 2. Assessing and selecting the QFD based product, which is focused on environmental friendliness. 3. Analyzing the Research perspective of the Product development process and eco-design. The review was carried out based on the eco-design of the product development and its operational criteria using QFD techniques.

Chan and Wu [3] carried out various literature reviews on QFD for about 650 publications through various sources from reputed journals. They performed different ways of reviewing the method QFD and its importance in various fields of engineering, viz. Product Development, Quality Management, Customer Needs Analysis, Product Design, and Product Planning. These are the key areas where QFD

(Quality Function Deployment) can be applied to enhance products and services' quality.

Gonzalez et al. [4] analyzed the design furniture used in schools in developing countries based on Costa Rica as a base Point. They designed a “Dynamic Process Model for QFD.” This model facilitates the team to make efficient and effective decisions after giving due considerations to customers’ requirements. This approach ensures product safety and service features using a simplified form of QFD.

Gandara, Muriand Purba[5] researched to develop the right design for improved services of formaldehyde products, as per customers' requirements using QFD. In this study, an effective questionnaire was designed to capture customer satisfaction from respondents in a field survey.

Neira-Rodado et al. [6] developed “a novel integration of AHP (Analytical Hierarchy Model) and QFD (Quality Function Deployment).” They translated the customer requirements into technical descriptors and further rank them in their order of importance from high to low.

In reality, many of the customer requirements possess vagueness, which is resolved using fuzzy. This computes the impact of each requirement. Then the design alternatives were generated using the weights of the requirements through AHP. The independencies among the alternatives have been evaluated through DEMATEL. It is followed by the selection of the best design using QFD.

Rogers and Salustri [7] introduced pattern languages for product design to gather information and convey them to others with limited knowledge.

Shih and Chen [8] applied quality function deployment for the conceptual design of a future mobile or portable healthcare device. They coupled with analytical network process (ANP) and theory of inventive problem solving (TRIZ). The results of the combined approach help to characterize priorities of the product of concern.

Cherif et al. [9] formulated an imprecise goal programming model to optimize the optimum target levels of engineering characteristics of QFD such that customer satisfaction is maximized subjected to resource limitation and market competition.

Yang et al. [10] proposed a hybrid method, which uses the theory of inventive problem solving coupled with KANSEI to evaluate quality function deployment processes for developing new product design in its initial phase. This research uses a numerical rating scale base on the questionnaire, factor analysis, and AHP at the first instance.

Next, a correlation matrix and interrelationship matrix of Quality Function Deployment is used to establish critical innovation points. This results in many alternative designs suitable inventive principles, Design rulers, and crucial design zones. In the end, the Kansei evaluation framework of the best design alternative is discussed. This method is used to design innovative car seat design.

Ionica and leba[11] made an attempt to integrate a new product development process with quality function development (QFD). They increased the robustness of the product design through the voice of customers. The results of QFD focused on determining the requirements, which are useful for the design phase and product development phase.

Falk and Schmitt[12] emphasized the fact that the product must have quality and value for money instead of having only the attractive feature. They directed their study by giving importance to the determination of customer requirements and integrating them into the technical descriptors in the process of new product development,

Sivasamy et al. [13] carried out a survey to capture the characteristics of different QFD models. As everybody knows that the objective of any QFD is to translate the customer requirements into technical descriptors, they identified different features of QFD studies carried out in the past and compared the computational complexities of them. The complexity of QFD is reduced using the Total Quality Function Deployment (TQFD) technique.

Moldovan [14] used Quality Function Deployment coupled with knowledge management to determine customer requirements of a product to rank the technical descriptors of a product for a new product manufactured by a mineral water company.

Mrugalska and Tytyk [15] carried out a review and recommended advanced technology to extend the use of the product in varied conations. This study has been oriented to improve the reliability and safety of the product by considering the aspect of uncertainties, which will prevail in reality.

Lu et al. [16] concentrated on the emotional and psychological needs of customers along with the functional needs of the customer of a product of interest. Such consideration would definitely improve the success of the product in the market in terms of overcoming the competition and improved market share of the product. This design involves interaction among people, products, and the environment. They applied this approach to a baby bicycle design and found that it had a greater positive impact on the product in the market

2.2 . QFD in Market segment selection and Evaluation:

Luu Quoc Dat, Thanh Thi Phuong, Hsing-Pei Kao, Shuo-Yan Chou, and Pham Van Nghia [1]

In this research, the authors have done some analysis on market segment evaluation and selection of target markets. In today's scenario, these are the two critical activities of all

companies. In order to evaluate and choosing of appropriate market segments, several decision-making attributes must be considered in the process of evaluation. In this paper, the focus is made on new integrated Fuzzy Quality Function Deployment (QFD) to aid the market segment selection. The proposed approach of research using QFD must have the ability to understand the features of Market (What's) in order to fit the company's strength (HOW).

The computational method is illustrated by means of the case study. Finally, this research compares the proposed approach with the Fuzzy QFD approach, demonstrating the advantages of the proposed approach.

Chih-Hsuan Wang, Jiun-Nan Chen [2] In this research, it is observed from the fact that in a growing fast global marketing environment launching new products in the customer market segments is said to be a challenge. Also, many firms now try to launch the products within a shorter lead time. In this study, a fuzzy MCDM (Multi-criteria decision making) based QFD which integrates Fuzzy Delphi, Fuzzy DEMATEL (Decision Making Trial and Evaluation Laboratory) with LIP (Linear Integer Programming) is decided to support an enterprise with more product mix in a collaborative way. In this research, Fuzzy Delphi is used to collect marketing information or data from various customers. Fuzzy DEMATEL is used to solve the priorities of technical attributes in a market-oriented manner, and LIP (Linear Integer Programming) is used to enhance the maximum capability of the product as per the vendor's budget constraints.

Ze-Ling Wang, Jian-Xin You, and Hu-Chen Liu [3] Quality Function Deployment (QFD) is a widely used quality system tool for converting customer requirements (CR's) into engineering design requirements (DR's) of products or services. The classical QFD analysis has been criticized based on the limitation such as the relationship between customer requirements and Engineering design Requirements. The assessment of customer requirement weights and the prioritization of Design requirements are studied using QUALIFLEX (Qualitative Flexible Multiple Criteria Method) approaches for tackling QFD problems with weight information. Finally, an analysis of the market segment selection problem is conducted to demonstrate and validate the proposed QFD approach.

K.G.Durga Prasad, K.Venkata Subbaiah, K.Narayana Rao, and C.V.R.S.Sastry [4] In this research, authors have studied the importance of customer preferences using market segmentation by forming a basis for the house of quality matrix. In the conventional QFD approach, the hierarchy structure of consumer needs is formulated through various assignments of weights for customer needs. The priority weight ages ratings of customer needs may be different for various needs. In this paper case study is presented to illustrate domestic refrigerator working and functions using

QFD as a proposed methodology to establish the different preferences of customer needs in detail.

Züleyhan Baran and Mehmet Selami Yıldız [5]The main aim of this paper is to consider the requests made by the various customers for products in order to maximize customer loyalty as well as retention by applying modern management tools like QFD methodology (Quality Function Deployment). In this paper, QFD methodology is used to assess the quality of fast food industries with the aim of giving quality services within a short lead time.

Mohammad Hassan Pourhasomi, Alireza Arshadi Khamseh, and Yaser Ghorbanzad [6] In this research, authors have addressed various competing pressures faced by service sectors around the globe.

Quality plays an important role in the banking industry, and customer service satisfaction is considered the most important goal in the field. The proposed study aims to integrate two approaches of Quality Function Deployment (QFD) and Kano's Model through the implementation of AHP (Analytical Hierarchy Process). In this research, the authors made an attempt to identify the different priorities of customer's requirements in the banking industry. The result proves that the consumer preferences are different before and after applying KANO'S model in the planning matrix of QFD.

Andreas C. Georgiou, Katerina Gotzamani, Andreas Andronikidis, and George .N.Paltayan [7]

The proposed research uses the Quality Function Deployment (QFD) in order to assess and transform the customer's needs into required achievable goals for enhancing the capacity requirements. Specifically, this study aims to focus on the selection criteria "wants" of the bank in Greece. Customer "wants" is related to key product market segments to formulate the house of quality matrix. A specific questionnaire was designed based on the list of selection criteria that was drawn from past surveys. Nearly 549 questionnaires are administered to the customer of a major bank in Thessaloniki, Greece.

Sheng Teng Huang, Yoshida Shigeru[8]In this research, authors have strongly focused on the national policy guidelines for logistics industries as published by Japan comprehensive logistics policy 2012 plans to efficiently integrate transportation mode and establish a complete global logistics network to meet the ever-increasing needs of demand for advance logistics infrastructure. As observed from the survey that nearly 70% of the firms in Japan and 40 % of the firms in the US prefer to outsource their major logistics distribution channels. The main objective of this paper aims to improve the service quality of fourth-party logistics service provider and applies Quality Function Deployment to explore the key performance of quality improvement. Customer retention through achieved

satisfaction is said to be a major task in the logistics industry. The Quality Function Deployment is one of the unique features by cross-correlation analysis between customer requirements and technical measures.

Ibo van de Poel [9] It is noted from the survey QFD (Quality Function Deployment) is a famous and widely used tool in the product development Industry. QFD tries to focus on setting objectives for improving product characteristics by following better marketing research. In this research, the main aim is to focus on fundamental aspects of QFD and its limitations, which are applied by taking practical applications like customer market segmentation. In this research, the major deviation observed is the impossibility of converting individual into customer demands as overall in total measures.

Andreas Helferich, Georg Herzwurm, and Sixten Schockert [10]

In this paper, a strong focus is made on understanding the competitive business atmosphere with respect to today's scenario, it is evident that companies must be able to offer products as per the consumer's requirements. Software product lines must have the ability or potential to support industries by offering a large variety of products of various types. But even though offering a large range of varieties does not influence the increased number of profits. The job of product portfolio Management is the enhancement of product portfolio that optimally satisfies the consumer needs at the same time, limits the number of products offered. In this paper, QFD is used to demonstrate the product portfolio planning; thus, it offers potential benefits.

Dinmukhamed Kelesbayev, Kuantbek Kalykulov, Yermek Yertayev, Altynay Turlybekova, and Akhmet Kamalov [11]

In this paper, the importance of quality improvements in Technical education universities are considered as the primary objective of the research. But however, it is considered that raising the Quality of education at par with the international level is a big challenge to all technical universities in today's economic world. In this study, QFD is used as a systematic method for improving the quality of education with respect to the countries demographical culture. This study is about the demand of course students from universities and reveals the quality of education services at the best satisfactory level.

SungChunChoi [12]

In this paper, the focus is made on product platform design and Development is a process that involves different stakeholders, both internal and external, within and away from the organization. Although there are numerous methods in product design platform such as generation, selection and optimization have been proposed and executed through various case studies presented in this paper. In this paper, water purifier product platform options were generated and assessed for their effects on the value chain, such as organization structure, product line

configuration, economic effect, and preferences of various stakeholders.

Xiaosong Zheng, Petri Pulli [13] In this research, QFD is used for improving customers' requirements in mobile services applications. Conventionally QFD is used in Product manufacturing lines. In this paper, QFD is used in the mobile service industry, which is a highly challenging industry in information security systems. This work case study is carried out to conduct mobile e-learning services for university professors and students using QFD methodology.

Evrin Kabukcu [14] In this paper author addressed the quality concepts of the fashion industry using QFD (Quality Function Deployment). The fashion industry is said to be increasing popularity in today's conditions due to the rapid cycles of products, sustainable products, and processes in terms of creativity and innovative approach are desired. In this study, the QFD house of the brand was designed with the QFD approach. At this juncture, experts from fashion industries evaluated the brands of products using the QFD method. Thus Technical descriptions and social aspects of products are analyzed and collected together.

Liang-Hsuan Chen and Cheng-Nien Chen [15] In this research, authors used to focus target market segment based on customer specification or needs using QFD (Quality Function Deployment). In this paper mathematical model is proposed to find the level of target market segments. From this numerical model overall customer satisfaction level is measured and evaluated.

A.I.A. Costa, M.Dekkar, and W.M.F Jongen [16] This paper presents a detailed literature review about the applications of the food industry with the aid of the QFD tool. This review is extended with various methodologies involved in the practice of the food industry. The benefits, applications, and challenges in using QFD are discussed.

SUMMARY OF REVIEW:

From the above review, it is noted that several authors have contributed their ideas to improve the quality concepts in product design using the QFD tool, along with they used various additional techniques like DEMATEL, AHP, and KANSEI MODEL, etc. to evaluate certain parameters.

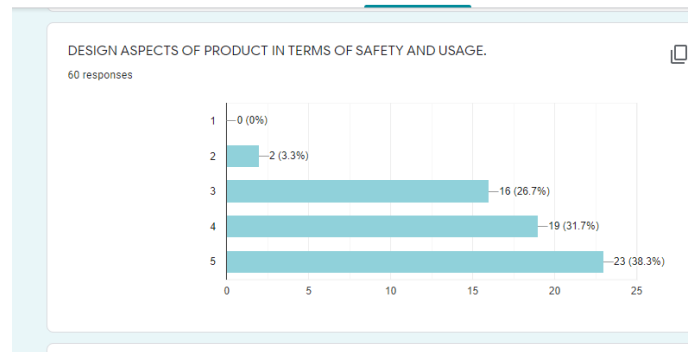
Case study:

In this paper case study is presented on a consumer product (Iron box) using a survey-based technique called google spreadsheets. The form template is created based on the design aspects, aesthetics appeal, safety, and Maintenance, costs, etc. The responses are studied from 60 customers using google forms. The weights are assigned from a 1 to 5 scale ratio. The sample responses are shown in table 1.

Table1. Responses from various customers

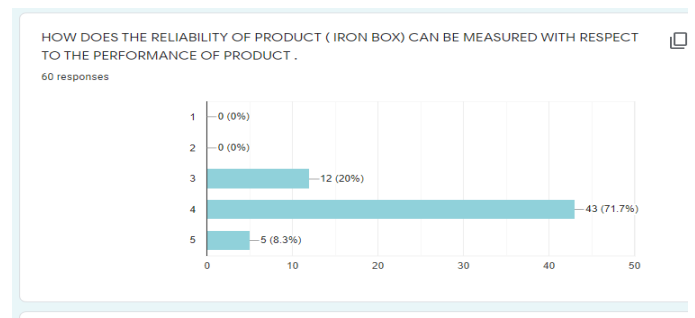
Results and discussions:

Based on the statistics, it is indicated that 38 % of the respondents are given preference for design safety of the product functions as shown in the graph.



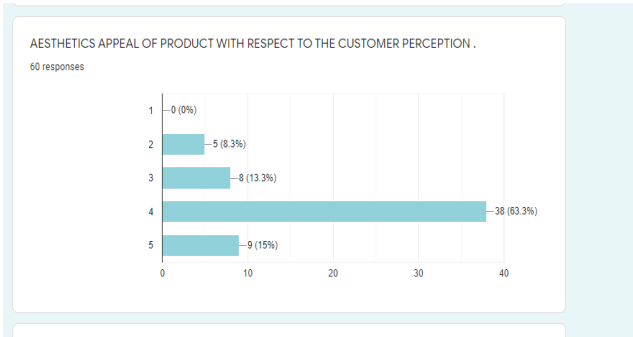
Graph 1.

In the next level of discussion, it is stated that nearly 71.7% of the respondents given importance to the reliability of the product performance.

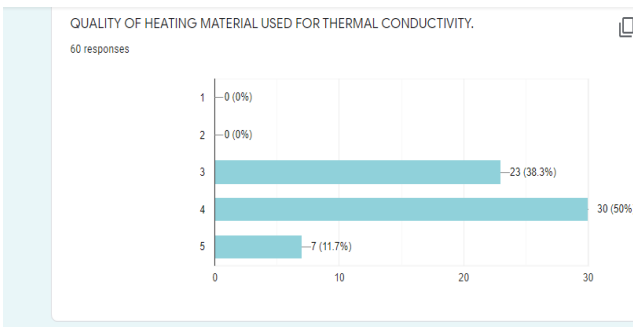


Graph 2

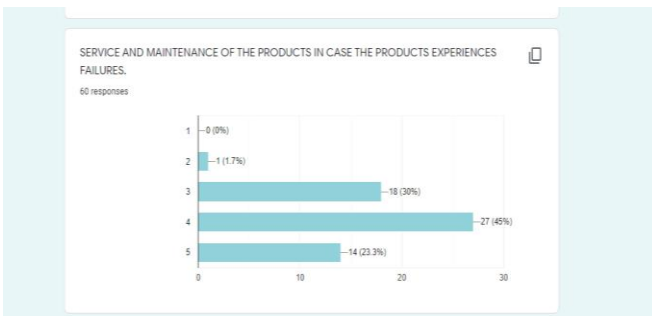
From graph 3, it is shown that 63.3 % of the customer's given importance to aesthetics



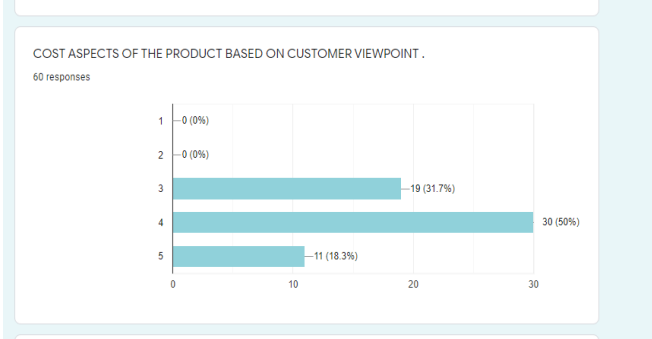
From graph 4, it is observed that 50 % of the respondents given importance to the quality of manufacturing and materials used.



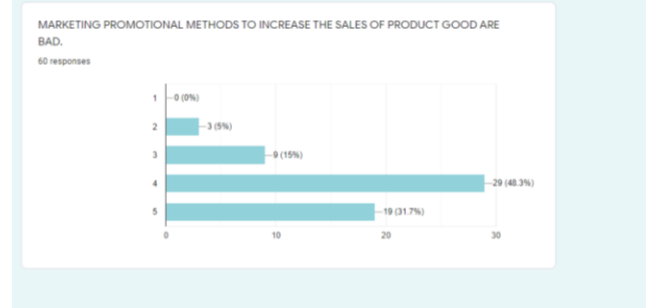
Graph 5 clearly indicates that 45 % of the respondents considered the service and maintenance aspects of products.



From graph 6, it is shown that 50 % of the respondents are considered their views based on the costs of the product.



From graph 7, 48.3% of the respondent's given importance to promotional methods to increase sales.



Conclusion

This brief paper review is focused on Modern Management tools and techniques to improve the accuracy of product design like Quality Function Deployment or House of Quality. QFD tries to merge both consumer requirements and technical product characteristics based on that relative weights are assigned accordingly. Determining the correlation between two factors and measuring the variation out of any two factors, namely say cost and Maintenance of the Product. Likewise, in the same way, several factors are measured whose relative weights are tabulated in the house of quality matrix. Also in another section in the literature study is carried out on market segmentation and selection of customer preferences using QFD in specific areas like consumer behavior, product target markets, product performance, customer loyalty in fast food restaurants, Banking Industry, QFD in logistics, product portfolio management, etc.

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